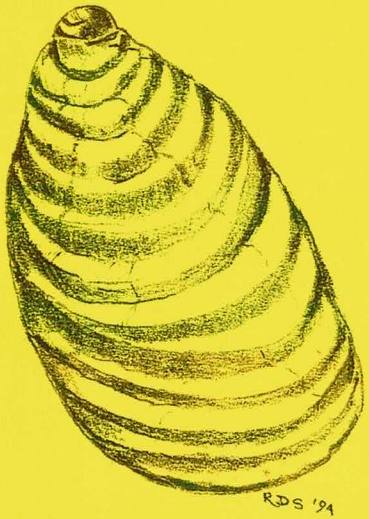

Inoceramus galoi

Monolis richmondiana

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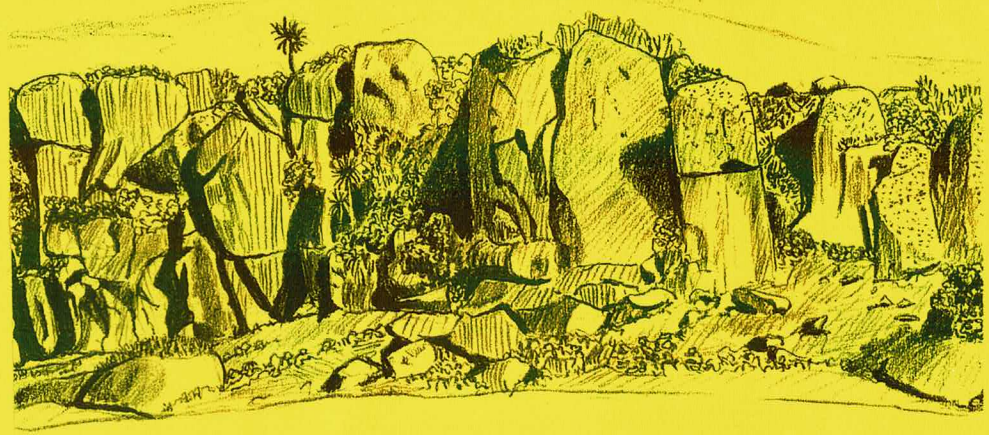
GEOLOGY
of
MATAMATA



Second Edition

R.D. Stanley

GEOLOGY

of

MATAMATA

R D Stanley

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INTRODUCTION

The Matamata district between Ngarua and Tirau is made up of

1. The Matamata plain, closely settled and intensively farmed, occupying the southern end of a major structural feature, the Hauraki Rift.
2. The uplifted, forested block of the Kaimai Range to the east of the plain
3. An area of downland and hills to the west, separating the plain from the Waikato Basin.

The geology of the district shows a remarkable variety of rocks of different ages and origins, including ancient marine sediments, volcanic lava and ignimbrite flows, and river-laid sands and gravels of various ages. Faulting has split the land and layers of volcanic ash from the volcanoes of the Taupo Volcanic Zone have mantled the surface, providing the parent materials for fertile soils.

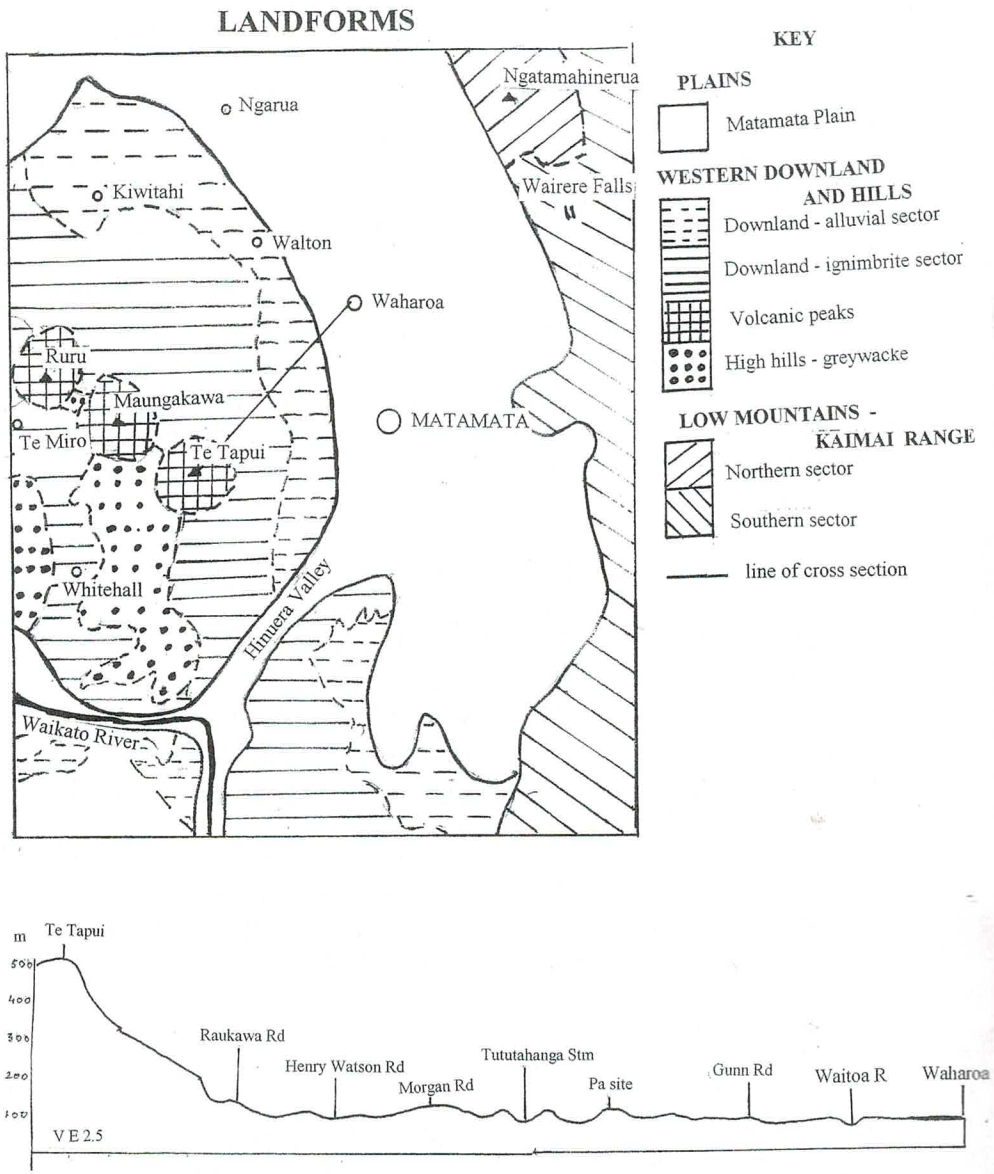
This book is intended for anyone who is interested in the story of our district's fascinating past. No formal training in geology is required. Although geological terms are used throughout, these are explained in the glossary or in the text.

In addition to a description of the geology of the district there are sections dealing with volcanic ash deposits, the part played by geology in everyday life, geological hazards, and a number of field excursions which can be undertaken by car or on foot.

References and suggestions for further reading are given for those who wish to study Matamata's geology in greater depth.

In this second edition, the text has been completely revised and updated and a considerable amount of new material has been included.

THE AUTHOR
R D Stanley has an M A (Hons) degree in Geography from the University of Auckland. He has a particular interest in earth sciences and is a member of the Geological Society of New Zealand.



LANDFORMS OF THE MATAMATA DISTRICT

The Matamata district is made up of three distinct landform units, the Matamata Plain, the western downland and hills to the west and the Kaimai Range to the east.

THE MATAMATA PLAIN

The central structural feature of the district is the sediment-filled Hauraki Depression, which is bounded to the east by the north-south trending Hauraki Fault and the uplifted block of the Kaimai Range and to the west by the belt of downland and hills which separate it from the Hamilton Basin.

The rift is made up of a series of fault-angle depressions extending over 300 km from Whangarei to the Taupo Volcanic Zone (Henrys, S A 1985) Geological, geophysical and paleomagnetic evidence indicate that rifting probably began in the late Pliocene to early Pleistocene periods (about 3 million to 2 million years ago). Geophysical evidence suggests that the floor of the depression has been downfaulted to depths of 800-1000 metres (Hochstein et al 1984)

Before the onset of rifting the landscape would have been one of greywacke hills similar to those found further west, dominated by the andesite volcanic peaks of the Kaimai Range.

Over the last two million years the depression has been filled by the lavas and ignimbrites of the Kaimai volcanoes, the Kiwitahi volcanoes and ignimbrites from the Taupo Volcanic Zone, and by a huge volume of alluvial sands and gravels, the products of eruptions in the Taupo Volcanic Zone transported here by the Waikato-Waihou river systems. These in-fill materials underlie the surface of the present day Matamata-Hauraki Plain. A drill hole near the Waharoa airport shows the presence of two ignimbrites at depths of 61m and 162m. The upper ignimbrite is inferred to be the

Ongatiti (or possibly the Rocky Hill) Ignimbrite and the lower one is the Waiteariki Ignimbrite.

The alluvial plain is the youngest landform feature of the district, dated at about 18,000 years before the present. It is the surface of a very large alluvial fan with its head at the western end of the Hinuera Valley and its toe far to the north in the Hauraki Gulf. At its head it is 90m above sea level. It slopes downwards towards the north at about 1.5m per kilometre. At Matamata it is about 80m a.s.l. and at Ngarua about 30m a.s.l Its eastern side is drained by the Waihou and its tributaries, including the Mangawhero Stream, and its western side by the Waitoa River. All these river systems have incised their channels below the surface of the plain over the last 10-15,000 years.

The surface of the plain is not completely flat but has a micro-topography of shallow ridges and swales related to the braid bars and channels of the braided river system which occupied the area during the Last Glaciation, up to about 18,000 years ago. This micro-topography is more obvious when one travels across the plain in an E-W direction, at right angles to the general flow of the former river. The swales tend to have damper soils and poor drainage and this is reflected in the types of plants that grow there, including moisture-loving species such as buttercup.

THE WESTERN DOWNLAND AND HILLS

This is the most varied of the three landform units.

The Downland

To the west of the Matamata Plain is a belt of rolling downland with accordant summit levels just over 100m a.s.l.

The downland represents the dissected surfaces of

(i) a former alluvial plain (Karapiro Surface) forming the eastern sector and

(ii) a flat-lying ignimbrite sheet (Ongatiti Ignimbrite) forming the western sector.

Both of these surfaces are much older than the Matamata Plain. They have been cut into by the tributaries of the Waitoa and

Piako river systems to form the present day landscape of downlands and valleys.

The Volcanic Peaks

Rising sharply above the downland are the peaks of three conical hills, Te Tapui (492m), Maungakawa (495m) and Ruru (482m), the eroded stumps of ancient volcanoes. The radial drainage pattern of these peaks feeds mainly into the Piako River system.

The High Hills

A third element in this rather complex landscape is an area of hills in the south-west of the district, intermediate in height between the downland and the volcanic peaks, developed on a hard sandstone rock called greywacke.

These hills have rounded summits and broad ridges and reach heights of up to 300m.

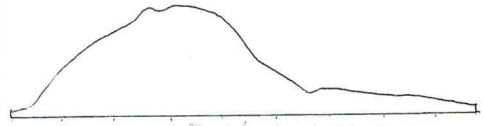
THE KAIMAI RANGE

The Kaimai Range has been uplifted along the Hauraki Fault, which forms its western boundary. It presents a steep scarp face to the west and slopes more gently eastward into the Bay of Plenty lowlands.

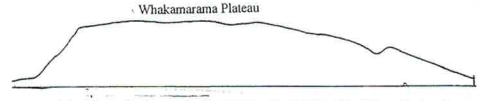
North of a line about 4 km south of Gordon the range is quite rugged with peaks up to about 800m a.s.l., e.g. Pukepenga (841m), Ngatamahinerua (848m), and Wahine Rock (795m), and reaches its highest point in Mt Te Aroha (952 m). This section of the range owes its character to past episodes of andesite volcanism.

The western side of the range in this section is drained by short, fast-flowing tributaries of the Waihou River, many occupying steep valleys and rocky gorges. On the eastern side a complex pattern of streams draining larger catchments flow eastward into the Tauranga Harbour.

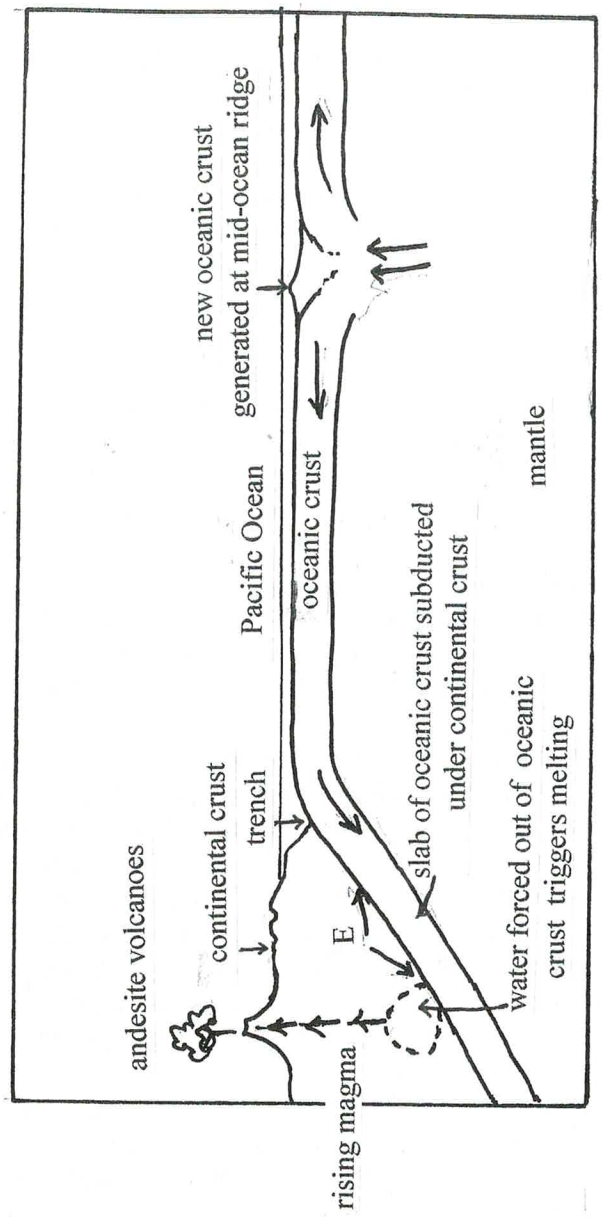
The southern section of the range between Gordon and SH29, the Whakamarama Plateau, is lower and more even in elevation with an average crest height of about 500m a.s.l., and owes its character to the Waiteariki Ignimbrite sheet.



Kaimai Range: Northern sector: Cross section about 2km north of the line of the Kaimai Tunnel, near Pukepenga Peak.



Kaimai Range: Southern sector. Cross section about the line of the Wairere Track and Falls.



E - zone of deep earthquakes

Plate Tectonics, Subduction and the formation of Andesite Volcanoes

FORCES WHICH HAVE SHAPED THE LAND

(1) PLATE TECTONICS

New Zealand lies on the boundary between the Pacific and the Australian crustal plates. East of the North Island the oceanic crust of the Pacific Plate is sinking beneath the continental crust of the Australian Plate, a process called subduction. As the subducting plate descends the rocks of which it is composed heat up and water is forced out, lowering the melting point of overlying crustal rocks, giving rise to a line of andesitic volcanoes on the surface. These are known as subduction-related volcanoes. The movement of the two plates against each other causes the many earthquakes experienced along the plate boundary. These features are responsible for the Pacific 'Ring of Fire', a zone of volcanoes and earthquake which mark the edge of the Pacific Plate.

(2) SEDIMENTATION

Rivers pour sand, silt and mud into the sea where it builds up on the continental shelf or is carried by submarine slumps, avalanches and turbidity currents over the edge of the shelf and down submarine canyons into the ocean depths.

Over the course of millions of years sediments may accumulate to a thickness of many kilometres. The great pressure and heat generated in this process cause chemical changes in the pile of sediments, producing new minerals and consolidating the soft original material into harder sandstones, siltstones and mudstones.

Sometimes shells or bones of marine creatures are preserved in the sediments as fossils.

Other types of sedimentary rocks, notably limestones, are formed from accumulations of the calcareous shells of marine life, or precipitated out from seawater under certain conditions.

(3) **UPLIFT**

Eventually the pile of sediments may be raised above the ocean by movements of the crust, usually associated with the boundaries of the major crustal plates.

It was large-scale epeirogenic or 'tectonic' uplift which elevated the land mass of ancestral New Zealand above the sea during the Mesozoic era. This was related to our country's location on the boundary between the Australian and Pacific plates of the earth's crust.

This is the mechanism which has produced our major mountain ranges, including the Southern Alps and the Tararua and Ruahine Ranges, all of which are made of a hard marine sandstone called 'greywacke'.

The Kaimai Range is also the product of uplift, but of volcanic rather than sedimentary rocks.

(4) **FAULTING**

A fault is a fracture in the earth's crust along which the opposite sides have been displaced upward, downward or laterally . There are three important faults in the Matamata district.

(i) **The Hauraki Fault**

The steep western face of the Kaimai Range marks the trace of the Hauraki Fault, a major structural feature of the North Island. This fault extends northward to the vicinity of Whangarei and south at least as far as Tokoroa. Along it the Kaimai block has been elevated and the Hauraki Plains area has been forced down to form the Hauraki Depression. The Waitekariki Ignimbrite, which was erupted just over 2 million years ago and caps the range above the Barton Rd quarry, has been carried down on the western side of the fault. This shows that there has been some 500 metres of vertical movement on the fault since the ignimbrite was erupted. However the Mamaku Ignimbrite, erupted 140,000 years ago, is not affected

by movement on the fault, showing that the fault has not been active in the last 140,000 years.

(ii) **The Okauia Fault**

The Okauia Fault runs parallel to the Hauraki Fault just west of the Old Te Aroha Rd, where it forms the steep western face of a prominent hill mass of Waitekariki Ignimbrite just south of Okauia (best seen from Springs Rd). It is on this fault that the well-known Okauia Springs occur.

(iii) **The Kerepehi Fault**

The Kerepehi Fault can be traced for about 50 km northwards across the plain. Tower Hill, near the Firth Tower Museum, and the small scarp immediately south-east of the Taihoa crossroads are surface expressions of the Kerepehi Fault.

Since the surface of the Matamata Plain has been disrupted by movement on the fault it is clear that the fault has moved within the last 18,000 years (the age of the plain surface), and should be regarded as active. However the fault has been active over a long period, and past movement is considerable greater than the 6 to 8 metres visible in the present-day landscape.

Geophysical work has shown that the greywacke sandstone rocks underlying the plain have been displaced by about 3 km. The last movement on the fault in the Matamata area was between 480 and 900 years ago, and the average time between earthquake events has been between 5,000 and 9,000 years.

(5) **VOLCANISM**

The style of eruption of a volcano and the resulting landforms depend on the chemical composition of the magma, the amount of gas it contains, and the presence or absence of water at the time of the eruption.

(i) **Basalt magmas** are associated with 'hot spots', rising plumes of upper mantle material from deep below the earth's crust, which

can occur anywhere and are not related to plate tectonics. These are referred to as 'intra-plate volcanoes'. Basalts are low in the mineral silica (<52%) and are relatively fluid, allowing gas to escape easily. Gas-rich basalts produce scoria mounds by a process of fire-fountaining (e.g. Mt Eden), and gas-poor basalts produce low-angle lava domes, or shield volcanoes, (e.g. Rangitoto). There are no basalt volcanoes in the Matamata district.

(ii) **Andesite magmas** are associated with the process of subduction and occur in association with plate boundaries. They are formed from a mixture of mantle material and the rocks of the continental crust. Andesites contain more silica than basalts (about 58%), are less fluid and, since gases cannot escape so easily from the rising magma, may be explosive. They typically produce **strato-volcanoes** (e.g. Egmont-Taranaki, Ngaruahoe. They are usually surrounded by a ring plain formed by rocks and mud carried down in flows called **'lahars'**. Andesite rocks occur in the Kaimai Range and the Te Tapui-Maungakawa-Ruru line of volcanoes.

(iii) **Rhyolite magmas** occur when rising magma melts the continental crust. They are high in silica (>62%) and are viscous, making it difficult for the gases to escape. Consequently gas-rich rhyolite eruptions may be violently explosive, especially if water is available during the eruption, as in eruptions from the Taupo Volcanic Centre. Such eruptions produce large volumes (up to 1000 cubic kilometres) of gas-rich fragmented rhyolite lava and pumice as ignimbrite flows (e.g. 'Hinuera Stone') and associated airfall deposits. Ignimbrites form flat-lying plateau sheets such as the Kaingaroa Plain and the Mamaku Plateau.

So violently explosive are these eruptions that the products do not accumulate around the vent to form a volcanic cone, such as Ruapehu or Ngaruahoe, but are distributed over a wide area and may be found hundreds of kilometres from the source. The removal

of such a large amount of material causes the surface around the vent to collapse, forming a circular depression, known as a **caldera**, which may be several kilometres across. Examples are the Rotorua Basin and Lake Taupo.

Gas-poor rhyolites, on the other hand, hardly flow at all and accumulate over the vent to form a **rhyolite dome**. Examples are Mt Ngongotaha at Rotorua and Te Weraiti on the Kaimai Range.

In the Matamata district ignimbrites occur in both the western downland and in the Kaimai Range.

(6) ALLUVIAL DEPOSITION

Sands and gravels laid down by the ancestral Waikato River and its tributaries form the plains and bordering high terraces of the Matamata district .

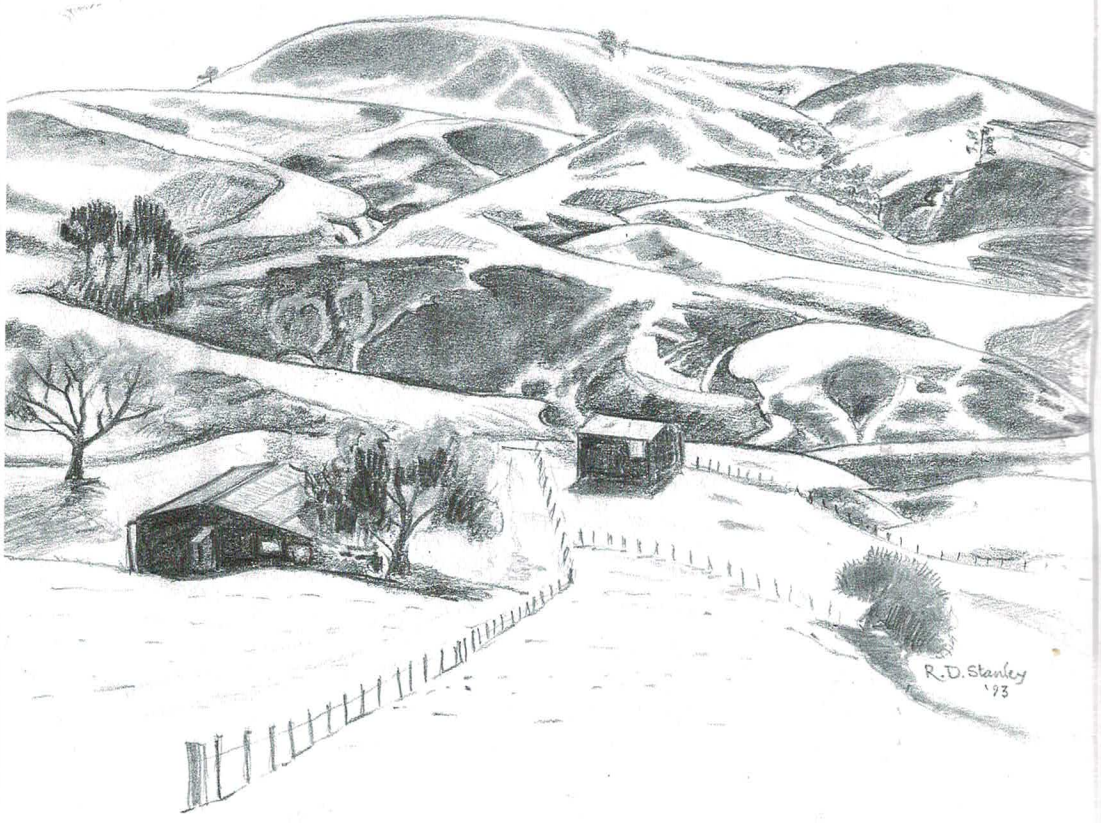
(7) WEATHERING AND EROSION

These forces have constantly operated to modify the initial landforms produced by the processes of uplift, volcanism and alluvial deposition. **Weathering** is the breakdown of rocks by chemical processes such as oxidation or by mechanical processes such as freeze/thaw. **Erosion** is the transport of weathered materials by mass movement under the influence of gravity (slumps, landslides and soil creep), by water (sheet wash, gullying and stream transport) and by wind (blowing of silt and dust, deposited as loess).

When we look at the rocks which make up the geologic record we are looking at the products of episodes of deposition, but when we study the landscape we are looking at the effects of processes which shaped products of deposition to form the topography of today. The gaps which separate depositional events are just as important as the depositional events themselves.

Evolution of the landscape - wearing down or wearing back?

Streams carve out valleys in the initial land surface and slumping, landslides, rock falls and sheet wash work away at the valley sides, gradually widening the valleys. The surfaces between the river valleys, remnants of the original surface, may remain relatively unaltered for tens or hundreds of thousands of years. We know this because the interfluves often have on them layers of volcanic ash up to a million years old, showing that these surfaces have changed very little since the ash beds were deposited.



Greywacke Landscape, Taotaoroa Rd

THE GEOLOGY OF THE WESTERN DOWNLAND AND HILLS

1. THE GREYWACKE HILLS - Our oldest rocks

What is a Greywacke?

Greywackes (the name means 'grey rock') are marine sediments of the Mesozoic Era, which comprises the Triassic (245-200 million years ago), the Jurassic (200-145 million years) and the Cretaceous (145-65 million years). The greywackes of the Matamata district are mainly Jurassic in age. Greywackes include hard sandstones, very suitable for road metal and concrete aggregate, and softer siltstones called argillites which, on weathering, fritter and break down to form a heavy clay. Fresh greywacke is a dark grey colour, but when it is exposed to weathering the minerals in the rock are oxidised to a rusty brown colour.

How the Greywackes were formed - the legacy of Gondwana

(i) Marine sediments and fossils: More than 140 million years ago the Matamata area was under the sea quite close to the eastern side of the ancient super-continent of Gondwana. Rivers of the continent discharged their sediments on to the continental shelf and much of this material was carried by mass gravity flows into the deep ocean beyond the edge of the shelf. Volcanoes erupted ash, which mingled with the river-borne sediments, sometimes forming recognisable beds. The source of the sediment which forms the New Zealand greywackes is thought to be in what is now Queensland.

In the shallower waters of the continental shelf the remains of marine animals accumulated, to be preserved as fossils. They

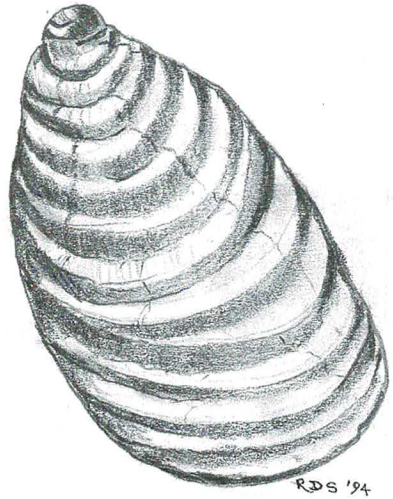
included the scallop-like Monotis (of Triassic age), ancestral squids called belemnites (Jurassic) and Inoceramus (Jurassic) which resembled a large, heavy shelled mussel. Rocks containing these fossils in abundance are found in the Marokopa-Kawhia-Port Waikato area. The deeper ocean lacked the abundance of life of the continental shelf and the only fossils found in rocks laid down there are occasional specimens in blocks carried down from the shelf in gravity flows. Since the greywackes of the Matamata district belong to the deep-sea sediments fossils are very rare, but a few specimens of Monotis and Inoceramus have been found in Hyndeman's Quarry at Kiwitahi.

(ii) Compaction and hardening: As the mass of sediments accumulated the lower part of the pile was subjected to both heat and pressure, which compacted the sediments and caused chemical changes which cemented the grains of sand and silt together to form a hard rock. Over the course of millions of years a great thickness of sediment accumulated. The hardness of many greywackes shows that they must have been buried to a depth of at least 4 kilometres. It follows that after they were uplifted above the sea, four kilometres of rock must have been eroded to expose the rocks now seen at the surface.

(iii) Uplift: When the huge pile of sediments began to rise the reduction in pressure resulted in the formation of a complex network of joints which became filled with white minerals called zeolites. This accounts for the white veining seen in greywackes, which is another indication of great depth of burial in the sedimentary pile.

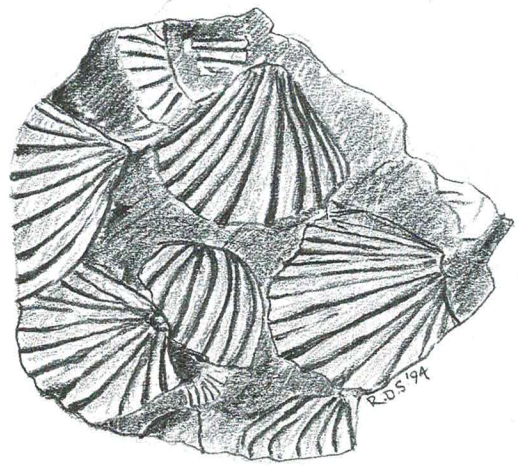
Over the course of geologic time the mountains of the emergent land mass have been worn away leaving today's landscape of hills and valleys, except in places where uplift is still going on, such as the Southern Alps and the main axial ranges of the North Island. Greywackes form the undermass of most of New Zealand, though

TWO FOSSILS FROM THE GREYWACKE AT HYNDEMAN'S QUARRY, KIWITAHI



Inoceramus galoi
Jurassic (120,000,000 years)
Inoceramus, a strongly-ribbed clam, is a common fossil in New Zealand Jurassic and Cretaceous sediments. Over this period it evolved rapidly, producing a succession of distinct species which have been valuable in defining the 15 time divisions into which the Jurassic and Cretaceous rocks have been separated. Some species were as large as 1.5m across.

Monotis richmondiana
Triassic (200,000,000 years)
Like the modern scallop, Monotis lived in beds containing large numbers of individuals. In the fossilised shell beds shells are packed together in vast numbers.



in many places they have been covered by younger sediments, both marine and terrestrial, and by volcanic deposits.

(iv) The break-up of Gondwana: About 80 million years ago the New Zealand land mass was split from the Australian part of Gondwana and drifted east, forming the Tasman Sea. This was part of the break-up of the Gondwana super-continent which resulted in the formation of the separate continents of Antarctica, Australia, Africa, the Indian sub-continent and South America.

Economic Uses of Greywackes: 'Greywacke' is a general term which includes both hard sandstone and a dark grey, fine grained siltstone (or argillite).

Greywacke rock is quarried at Taotaoroa Rd and at Kiwitahi. The fresh greywacke sandstones are very hard and make excellent road metal and concrete aggregate, while the weathered sandstone, which is brown-coloured 'rotten rock', is not suitable for road metal but can be used for farm tracks and the like.

The siltstones have a much lower strength and on weathering fritter away to a powder which, on wetting, turns to mud.

Where to see Greywackes: the greywacke hill landscape

In the Matamata district Greywackes are found in the west and north-west and are represented by areas of hill country with rounded upper slopes and broad interfluves. Characteristic features are the broad, deep amphitheatres which Professor M J Selby of Waikato University has interpreted as slumps formed between 13,000 and 1,850 years ago. Much more recent are the scars of shallow landslides, many of which have formed since the land was cleared for farming in the early part of last century. Today, much of the greywacke hill country is under pasture, with small patches of bush. In places there is a good covering of volcanic ash beds, the oldest of which may have been deposited a million years ago and

the most recent only within the last 2000 years. It is on these ashes that the modern soils have been developed.

A drive along Taotaoroa Road will provide an opportunity to see the features mentioned above.

2. THE KIWITAHI VOLCANICS

TE TAPUI, MAUNGAKAWA AND RURU.

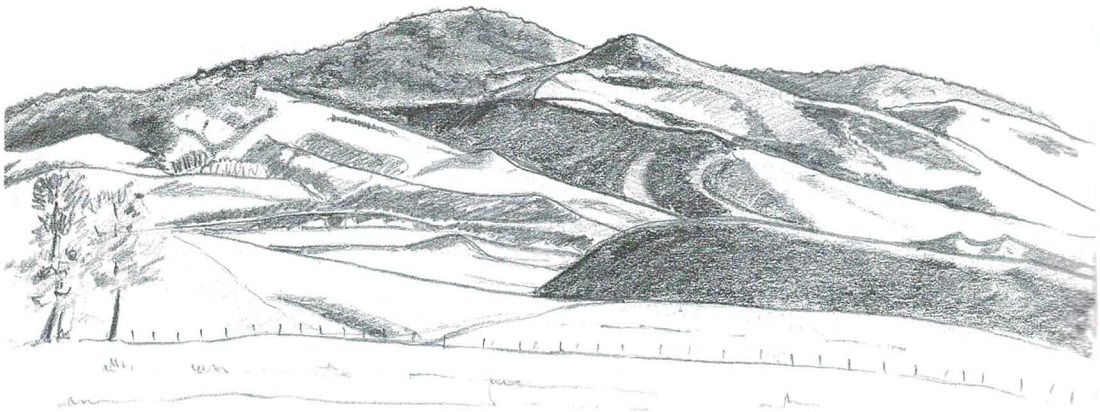
Between about 12 million and 5 million years ago a chain of andesite volcanoes was active along the western side of the Hauraki Rift. Activity began well to the north of our district, near Miranda, and moved southward over time, so the southernmost peak, Te Tapui, is the youngest and Maungakawa, Ruru and Kiwitahi are progressively older. These are the Kiwitahi Volcanics, which erupted andesite lava. An andesite volcano typically produces a cone such as Ngaruahoe, Taranaki-Egmont or Fujiyama.

These ancient volcanic cones have been deeply weathered and heavily eroded so that today they are but worn-down remnants. Outcrops of solid rocks are few; to see what the lavas of the Kiwitahi Andesite volcanoes are like we have to examine the scattered boulders found on their slopes. Ignimbrite flows have lapped around their lower slopes and they have been mantled with the ash of more distant eruptions.

The northernmost cones have completely disappeared from the landscape; only a few scattered rocks remain to tell us that they were ever there.

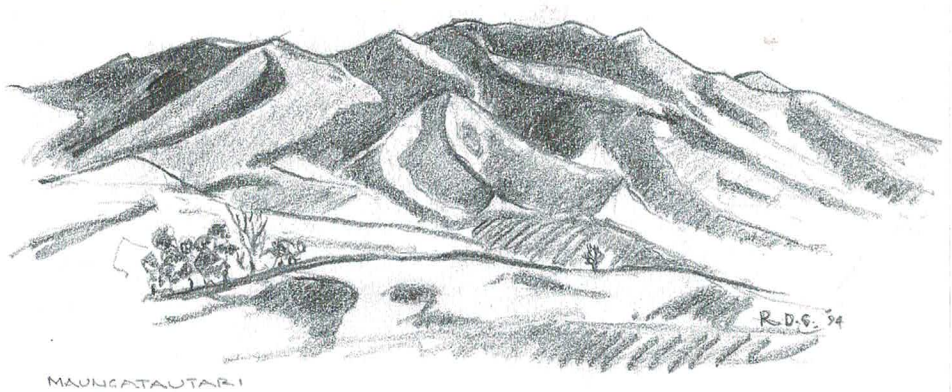
3. MAUNGATAUTARI VOLCANO

Maungatautari, a prominent landmark on the south-western side of the district, is an andesite volcano which has been dated at 1.8 million years. It appears to be an isolated volcanic centre not



Kiwitahi Volcanics

Te Tapui from Morgan Rd.



Maungatautari Volcano

directly connected with other andesite volcanoes of the Waikato region. Like the other volcanic peaks of the western margins it has been deeply eroded. Its lower slopes are mantled with bouldery avalanche flows or 'lahars', similar to those which form the ring plains surrounding Mt Ruapehu and Mt Egmont/Taranaki. This laharic apron extends up to 10 km from the mountain.

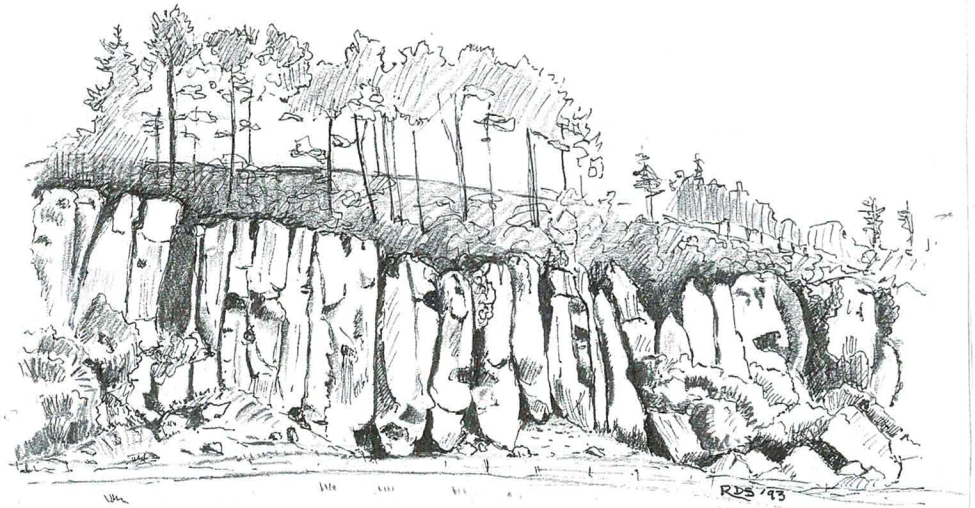
4. THE DOWNLANDS

(1) The Ignimbrite Downlands - the Ongatiti Ignimbrite (Hinuera Stone).

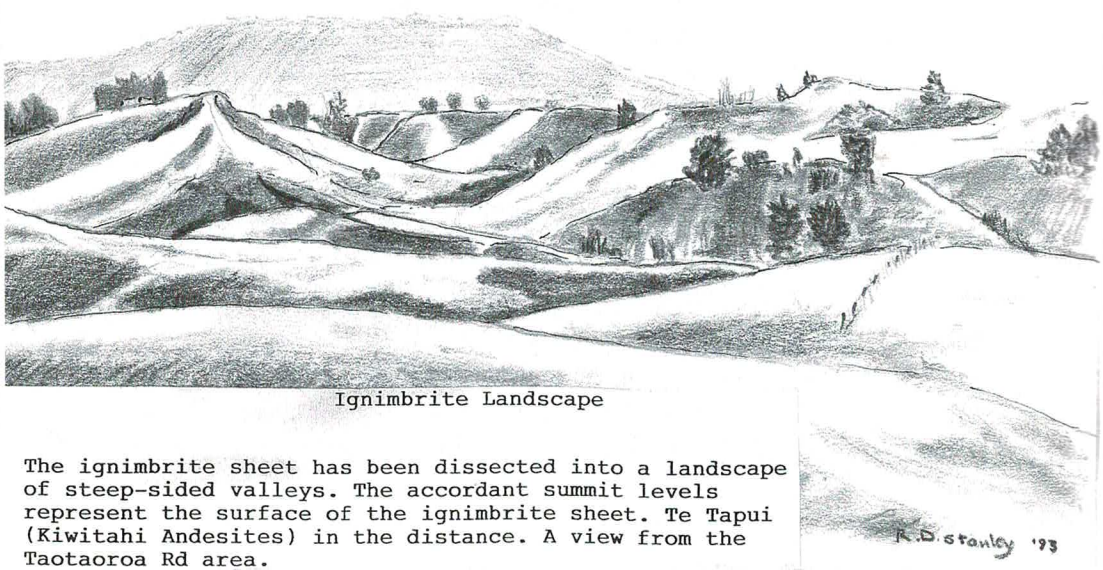
These form the western sector of the belt of downlands west of the Matamata Plain.

About 1.2 million years ago very violent eruptions in the Mangakino Volcanic Centre blasted out over 300 cubic kilometres of ignimbrite which covered, and spread total destruction over, an area stretching from Ngaruawahia to Taumarunui and the Bay of Plenty to Kawhia. This particular ignimbrite is known as the Ongatiti Ignimbrite, or Hinuera Stone. An outcrop of the same ignimbrite can be seen alongside SH3 just south of the 'eight mile junction' on the Te Kuiti-Awakino road. In the Matamata district it flowed around the lower slopes of the Kiwitahi volcanoes, buried the lower parts of the old greywacke landscape and extended eastwards across the floor of the Hauraki Depression, forming an extensive flat surface, the dissected remnants of which make up the western sector of the downlands through Richmond Downs, Kiwitahi and beyond. Further west the ignimbrite flow fills a valley in the greywacke hills from Whitehall to Te Miro.

This was only one of more than forty such eruptions, some even larger, which have occurred in the Taupo Volcanic Zone. Over the last 2 million years some 15,000 to 20,000 cubic kilometres of rhyolite, much of it in the form of ignimbrite, have been erupted in the T V Z. The Mangakino Volcanic centre is the



IGNIMBRITE COLUMNS,
HINUERA VALLEY



Ignimbrite Landscape

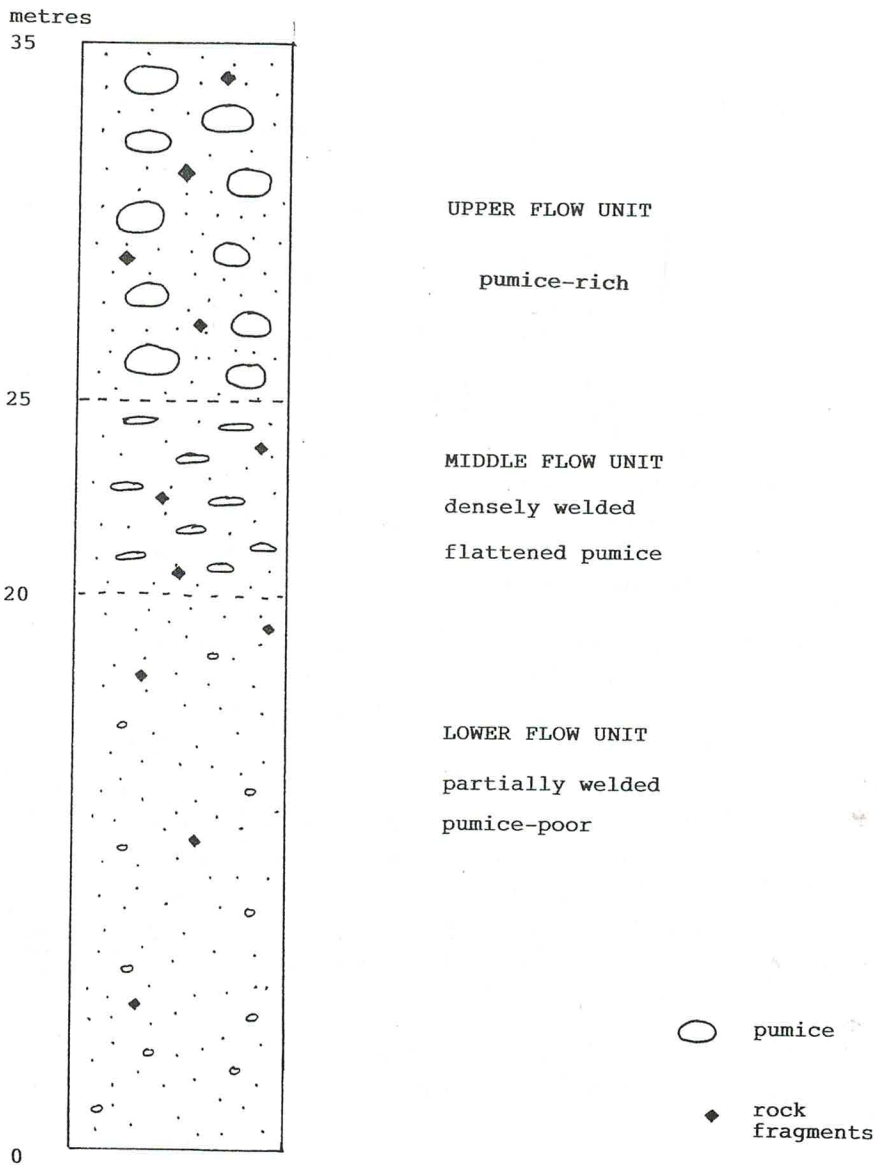
The ignimbrite sheet has been dissected into a landscape of steep-sided valleys. The accordant summit levels represent the surface of the ignimbrite sheet. Te Tapui (Kiwitahi Andesites) in the distance. A view from the Taotaoroa Rd area.

oldest of the caldera volcanoes of the T V Z. The others are: Whakamaru, Maroa, Taupo, Reporoa, Kapenga, Rotorua and Okataina.

Ignimbrites are formed from magma blasted to fragments by the explosive effects of gas pressures built up in the viscous rhyolitic magma and released as it nears the surface. The presence of water greatly increases the explosive power of the eruption. An eruption of this type produces huge volumes of fragmented rhyolite, pumice and volcanic glass, with a very high proportion of gas to solids. Also included are fragments of country rock plucked from the walls of the magma chamber. The mass of rock fragments and gases, at a temperature of 7-800 degrees C., pours as a gaseous emulsion at speeds of up to 900km an hour, flowing over lower-lying features of the landscape and around higher hills, which project like islands above the ignimbrite sheet. In particularly high energy eruptions the ignimbrite can flow up and over quite high mountain ranges. A homely analogy to an ignimbrite eruption is jam boiling over, or lemonade or champagne shooting from a bottle after shaking.

When the flow stops the still-plastic fragments weld together to form a solid rock of which Hinuera Stone is an example. Parts of the flow which cool quickly are less welded and therefore not as hard as those parts which cool more slowly. A densely welded ignimbrite can be very hard indeed. Lower temperature flows can produce an unwelded ignimbrite which is soft and easily eroded. Inspection of a block of ignimbrite will show the presence of lumps of pumice, often flattened by pressure while still plastic, fragments of rhyolite lava, shards of black volcanic glass and sometimes fragments of greywacke or other non-volcanic rock (xenoliths) caught up in the eruption.

Ignimbrites form flat-lying plateau-like surfaces such as the Mamaku Plateau and the Kaingaroa Plains. Even after they have



SECTION THROUGH THE ONGATITI IGNIMBRITE, HINUERA STONE QUARRY

been dissected by stream action their original form is reflected by broad interfluves and an accordance of summit levels which represent the original surface.

Alongside the Hinuera Valley the Ongatiti Ignimbrite is well exposed in the bluffs which are seen from SH29. The columns to be seen in the bluffs are the end product of the processes of cooling, river erosion and weathering. As the ignimbrite cooled it contracted, causing shrinkage cracks to form at right angles to the cooling surface. The Waikato River, flowing northward through the Hauraki Depression, cut into the ignimbrite sheet forming the valley we see today. The processes of weathering then worked away at the shrinkage cracks, opening them up to form the spectacular columns.

Closer examination of a section through the Ongatiti Ignimbrite shows that it consists of:

(i) a basal zone which is only moderately welded and is therefore relatively soft, and which contains very few pumice fragments. This zone cooled fairly quickly because it was in contact with the ground surface over which the ignimbrite flowed.

(ii) a central zone which is densely welded and therefore quite hard. The pumice fragments in this zone are flattened, showing they were still plastic when the flow stopped. Because this zone was the centre of the flow it cooled more slowly than the zones above and below it.

(iii) an upper less densely welded zone which contains large fragments of pumice and is comparatively soft. Contact with the atmosphere allowed this zone to cool more quickly than zone (ii).

'Hinuera Stone' has been quarried for many years. The first quarry was a small one about 3 km north of the present site, which

has been operating since 1954. The stone is used for a variety of building purposes, for which it is ideally suited.

Ignimbrite bluffs can be seen in the sides of many of the valleys in the ignimbrite sector of the western downlands. The ignimbrite is easily recognised by the columns which occur in the cliff faces.

(2) The Ahuroa Ignimbrite

Overlying the Ongatiti Ignimbrite is a slightly younger flow from the same source, the Ahuroa Ignimbrite, dated at about 1.19 million years B.P. (before the present time). Less voluminous than the Ongatiti, about 50 cubic kilometres, the Ahuroa is not seen extensively in the Matamata district, but the higher outcrops seen above the break of slope on the east side of SH29 in the Hinuera Valley are Ahuroa. It comprises a lower poorly welded greyish pumice-rich flow unit and an upper strongly welded unit. Boulders of Ahuroa Ignimbrite are found in the Karapiro Formation alluvial gravels.

(3) The Rocky Hill Ignimbrite

A third large volume (>300 km^3) ignimbrite from the Mangakino Volcanic Centre is the Rocky Hill Ignimbrite, dated at about 970,000 years B. P. It outcrops extensively to the south-west of the Matamata district.

(4) The Mamaku Ignimbrite

The Mamaku Ignimbrite was erupted from the site of Lake Rotorua about 225,000 years ago*. It is this ignimbrite which forms the Mamaku Plateau, and good outcrops may be seen along the main highway between Tapapa and Rotorua. Like the Ongatiti the Mamaku was a big one, over 300 km^3. The ignimbrite deposit covers 3000 km^2 and extends up to 50 km from the source.

Mamaku ignimbrite looks quite different from the Ongatiti. It is usually grey in colour, with powdery pumice fragments.

The prominent tors seen alongside the highway on the Mamaku Plateau are erosion remnants. They represent harder portions of the soft upper part of the ignimbrite flow. Severe erosion during the Last Glaciation period (40,000 to 10,000 years ago) removed the softer material, most of which was washed into the Hauraki Depression.

5. THE HINUERA VALLEY - THE PARTING OF THE WATERS

Cutting through the ignimbrite sheet like a knife slash is the Hinuera Valley, carved out by the Waikato River soon after the emplacement of the ignimbrite.

At the southern end of the valley, where SH29 meets SH1, is the Hinuera Disjunction, the place where the Waikato several times changed course from a route north through the Hauraki Depression to one westward into the Hamilton Basin.

At some time in the distant past, possibly well over a million years ago, a west-flowing stream was able, by cutting back into the upper part of its catchment, to intersect the course of a large north-flowing river, the ancestral Waikato, and divert it into the westward course previously occupied by the stream. The right-angled bend, or 'elbow of capture' has remained a feature of the landscape to the present day.

This river capture event has had a profound effect on the landscapes of the Hamilton and Hauraki Basins. In periods when the river was actively depositing alluvium it built its bed up to a

level higher than that of the alternative course. In time of flood it would beak through its levee and flow down the alternative course. The process was repeated many times, the river swinging from one course to the other or possibly sometimes following both at the same time.

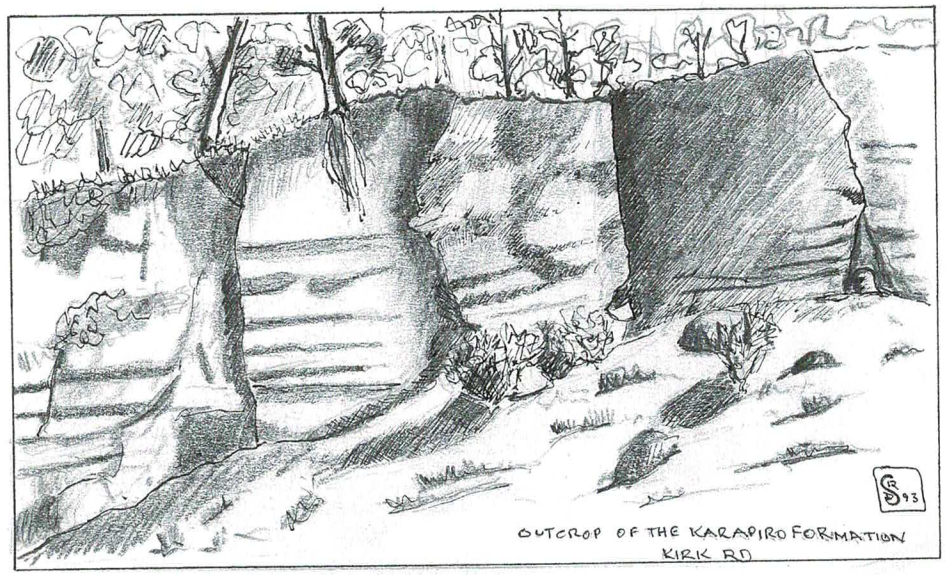
In this way similar sets of sediments were deposited in both the Hamilton Basin and the Hauraki Depression, the main depositional phases being those giving rise to the Karapiro and Hinuera Formations. The depositional phases were associated with periods of cold climate, or "ice ages". In the warmer inter-glacial periods the river entrenched itself in whichever course it happened to be following when warming began. At the end of the Last Glaciation, about 15,000 years ago, it was flowing into the Hamilton Basin. Since then, as can be seen at the disjunction, it has cut deeply into its own sediments and at Piarere is flowing well below the Hinuera Surface which marks its depositional surface in the Hinuera Valley.

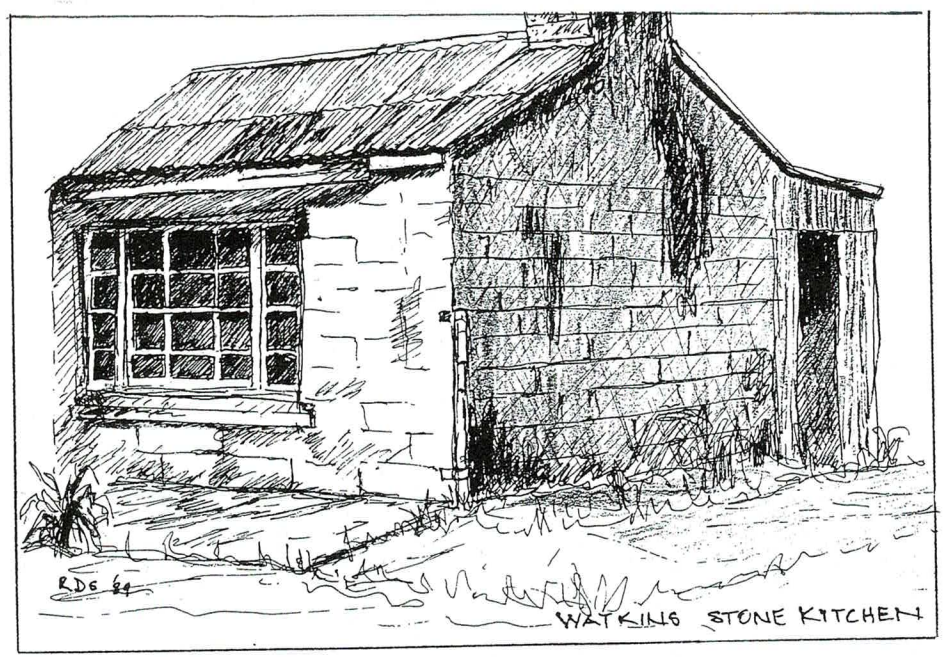
Of course the water level at Piarere is that of the man-made Lake Karapiro; the true river bed is well below lake level.

6. AN ANCIENT RIVER PLAIN - THE KARAPIRO FORMATION

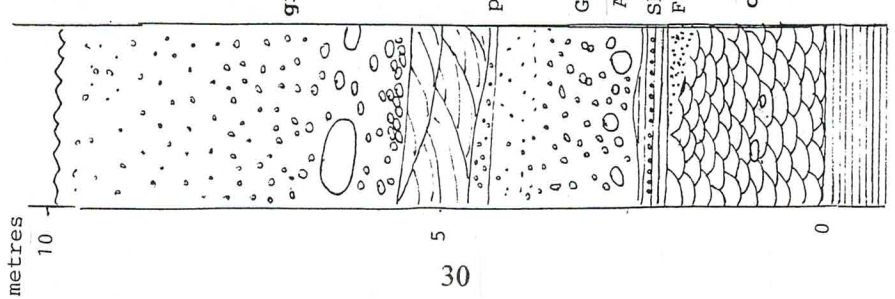
Along the western margins of the Hauraki Depression between Morrinsville and Matamata is an extensive set of alluvial terraces making up part of the Peria-Richmond Downs - Walton area. Now dissected into a rolling hilly landscape, the terraces are the remnant of a once-extensive alluvial plain.

The present surface is underlain by sands, gravels and occasional silty over-bank deposits which were laid down in a braided river system. The same type of alluvial sediments can be traced from Piarere westwards into the Hamilton Basin. Their age

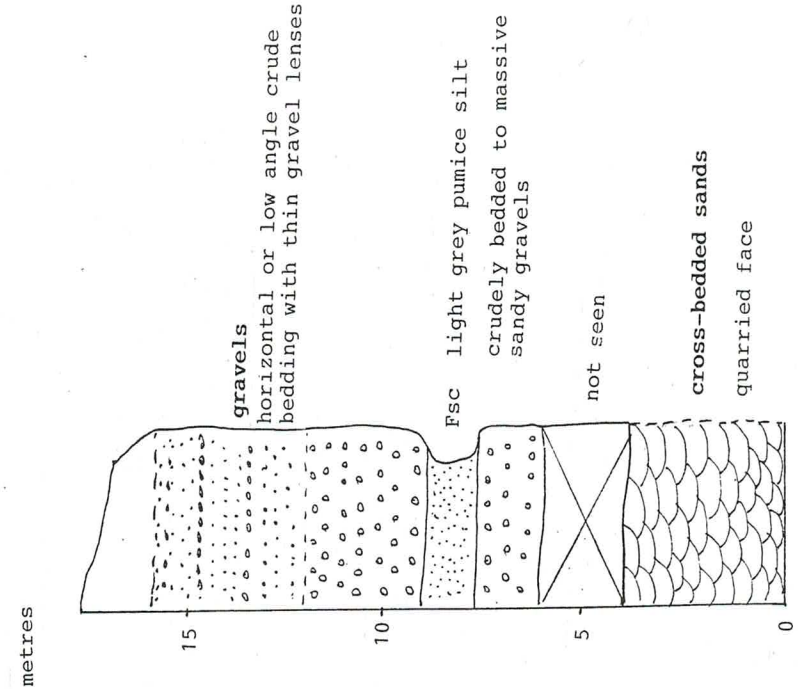




Watkins Stone Kitchen at Piarere was built in the 1880s by the Armed Constabulary, Using blocks of Karapiro Formation alluvial gravels quarried from an adjacent river Terrace. After more than a century the stonework is still in good condition.



GENERALISED SECTION THROUGH THE KARAPIRO FORMATION AT KIRK RD



SECTION THROUGH THE KARAPIRO FORMATION AT SCHERERS RD

can be determined within broad limits because they are overlain by a series of volcanic ash beds, the Hamilton Ash Formation, the oldest of which has been dated at 350,000 years before present (Pillans et al 1992). They must therefore be older than 350,000 years. Beneath them is the Ongatiti Ignimbrite, which shows that they must be younger than 1.2 million years. The name 'Karapiro Formation' has been given to this set of alluvial beds.

Study of the Karapiro Formation, then, tells us that more than 350,000 years ago extensive alluvial plains, similar to those we see today, occupied the Hauraki and Hamilton Basins. They were the product of an ancestral Waikato River which, as in the Last Glaciation, switched courses from time to time, sometimes flowing west through the Hamilton Basin and sometimes north through the Hauraki Depression.

Like the Hinuera Formation, which underlies the present day plains, the Karapiro Formation was deposited in a braided river system in a period of cold climate, a former ice age, and is made up of material of volcanic origin, much of it derived from the products of the Ongatiti and Ahuroa ignimbrite eruptions.

After deposition came to an end, in a period of warmer inter-glacial climate, the plain was dissected by stream action to form a landscape of low hills. In the Hauraki Depression the eastern part of the plain was carried down as a result of movement on the Hauraki Fault and subsequently buried by the deposition of the Hinuera Formation during the Last Glaciation, leaving only the western margins still exposed. In the Hamilton Basin also the lower parts of the Karapiro landscape were buried by the alluvium of the Hinuera Formation. Today low hills of Karapiro gravels project above the Hinuera Surface, e.g. beside SH1 between Cambridge and Hamilton.

Karapiro gravels can be seen in road cuts on Henry Watson Rd and along SH1 in a prominent road cutting just west of the SH29/SH1 junction at Piarere. The best exposures are on private land at Kirk Rd and Scherers Rd.

West of the Karapiro surface a similar downland topography has developed on the Ongatiti Ignimbrite surface.

GEOLOGY OF THE MATAMATA PLAIN

A product of a volcanic eruption and the ice age

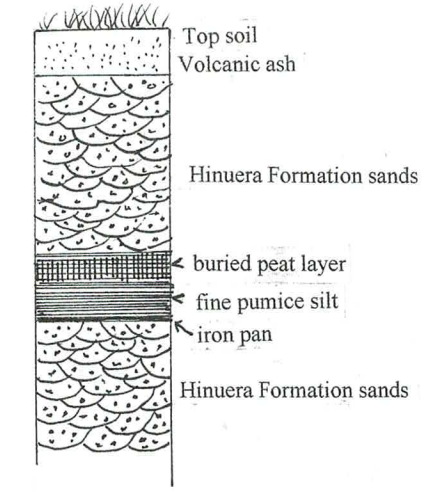
The Matamata Plain is the surface of a large, low-angle alluvial fan which slopes gradually northwards from its apex at the Hinuera disjunction at Piarere towards the Firth of Thames. Its toe, north of about Springdale, is buried under peat and other young post-glacial deposits. During the Last Glaciation, when the fan was being built up, it extended well to the north of the present shoreline because the sea level at that time (about 40,000 to about 18,000 years ago) was about 100 metres lower than it is today. This was because of the large amounts of water locked up in the huge ice sheets of the northern hemisphere.

The sands and gravels of the Matamata Plain originated in the huge Oruanui Eruption of the Taupo Volcano 26,500 years ago. This eruption produced 430 cubic kilometres of airfall deposits and 330 cubic kilometrea of unwelded ignimbrite, providing an enormous reservoir of loose material to be transported downstream by the Waikato River. (For comparison, the Tarawera eruption of 1886 produced about 1 cubic kilometre).

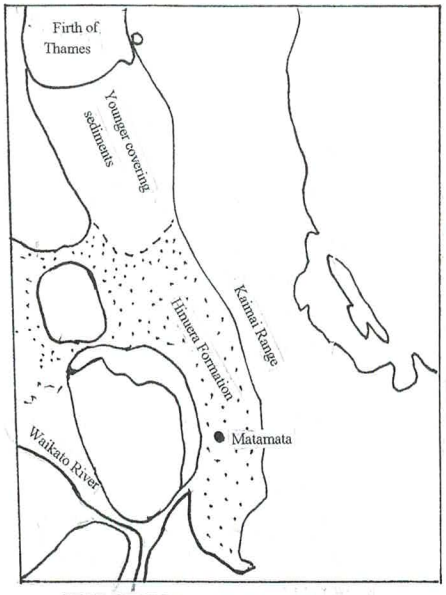
This easily eroded material was transported by the Waikato river and deposited in the river's lower reaches in the Hamilton Basin and the Hauraki Depression as it repeatedly switched its course between the two.

The processes of erosion were assisted by the cold climate during the Last Glaciation, between 40,000 and 15,000 years ago, which lowered the bush-line by up to 1000 metres.

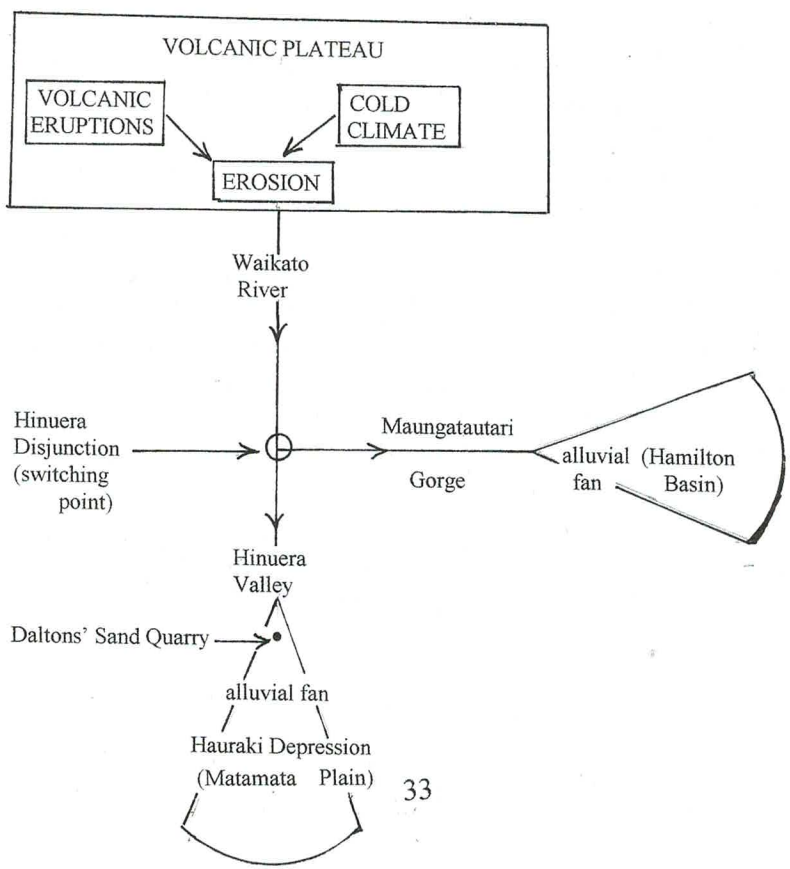
The sands and gravels which make up the fan consist of materials of volcanic origin - pumice and rhyolite fragments, quartz and felspar crystals and glass shards, with a small proportion (about 1%) of heavier dark-coloured minerals such as hypersthene, magnetite and augite. They are known as the Hinuera Formation,



SECTION THROUGH HINUERA FORMATION



THE HINUERA FORMATION IN THE HAURAKI DEPRESSION



and the surface of the fan, which marks the end of the depositional process, is the Hinuera Surface.

The Hinuera Formation covers about 2,000 square kilometres of the Hauraki Lowland and the Hamilton Basin. It tells the story of some 40,000 years of alluvial deposition in both these areas as the river alternated between them. In the Hauraki Lowland the Waihou and its tributaries also contributed to the deposition of sediment of volcanic origin. River channels formed a braided pattern similar to that seen in the Rakaia and other South Island rivers today. Sediment brought down by the river was deposited in migrating dunes on the channel bed and in braid bars which separated one channel from another. These deposits, which make up the bulk of the Hinuera Formation, show a characteristic pattern of scoop-shaped bedding, or 'current bedding' which can be seen in any sandpit or cutting which exposes a section through the formation.

As the river swung from side to side across the surface of the fan the pattern of channels was constantly changing, with new channels forming and old ones being abandoned. In times of flood the abandoned channels would become filled with silt-laden water so that in time layers of fine whitish pumice silt built up. Drainage through these over-bank silt deposits was poor, resulting swampy conditions in which rushes and other swamp vegetation flourished. Gradually a layer of peat was built up until the next channel change covered the peat in a fresh layer of sand. Buried peats have been preserved in the Hinuera Formation and because they are suitable for carbon dating they can be used to determine the age of the alluvium in which they are found. Ages of about 19,000 to 25,000 years have been obtained from buried peats found in the Hinuera Formation in the Matamata area.

Deposition of the Hinuera formation in the Matamata area came to an end about 18,000 years ago when the Waikato River

changed direction for the last time and took up its present course through the Karapiro Gorge into the Hamilton Basin.

This same sequence of deposition, course changes and downcutting had happened before, and the pattern of river-laid sands and gravels of a much earlier period of deposition can be seen in both the Hamilton and Hauraki basins. In the Matamata district these deposits, known as the Karapiro Formation, form the downland in the Peria-Richmond Downs area. They are at least 350,000 years old, and possibly much older.

The depth of the alluvial sediments in the Hauraki Depression, probably including Karapiro as well as Hinuera sediments, is at least 750 metres.

The Hinuera Formation in the southern part of the Matamata District

Between Matamata and Tirau most of the Hinuera Formation has been derived from erosion of the soft upper part of the Mamaku Ignimbrite. Cuthbertson (1981) has identified two Hinuera surfaces in this area, an older and higher one about 50,000 years old, referred to as the Hinuera 1 surface, and the 18,000-19,000 year old Hinuera 2 surface. The northernmost remnant of Hinuera 1 is an isolated small hill on the north side of Taihoa Rd North. In addition, Cuthbertson identified mass-emplacement deposits which represent large-scale slumping of the soft top of the Mamaku Ignimbrite. These can be seen in a big road cutting at the north end of Rangitanuku Rd.

Where to see the Hinuera Formation

Any sandpit or road cutting on the Matamata Plain will expose a section through the Hinuera Formation. Examples are the sand quarry at the corner of SH29 and Taotaoroa Rd, and Dalton's sand quarry on Hinuera Rd W. The road cutting on Mangawhero

Rd just on the Matamata side of the Mangawhero Stream originally showed a very good section including current-bedded sands, lenses of pumice silt and buried peats, but the cutting is now overgrown. The nearby sandpit also contains these features.

POST-GLACIAL EVENTS

Over the last 18,000 years eruptions in the central volcanic plateau have resulted in the deposition of a layer of volcanic ash (or 'tephra') on the Hinuera Surface. It is the weathering of this tephra that has produced the present-day soils of the Matamata Plain. Since the age of the tephra can be determined by radiometric methods it is also a way of dating the Hinuera Surface.

Since the end of the Last Glaciation the rivers of the Matamata area, instead of building up their beds, have been cutting down into their own deposits so that they are now well entrenched below the surface of the plain. This change is related to a warmer and less stormy climate, leading to greater vegetation cover and less erosion, and to a reduction in volcanic activity, all contributing to a reduced sediment load in the rivers. The Waitoa River occupies one of the old channels of the Waikato River.

SURFACE FEATURES AND SOILS OF THE MATAMATA PLAIN

The surface of the plain is slightly undulating, relating to the sand/gravel bars which developed in the constantly changing braided river channels of the alluvial fan. This micro-topography is more noticeable when one travels across the fan in an east-west direction at right angles to the general direction of flow of the river.

The bulk of the Hinuera Formation has been formed by in-channel sediment deposition. However during flood periods the river covered its flood plain and sediment-laden water was trapped in abandoned channels, depositing fine-grained pumice silt from suspension. Thus the low ridges, representing sand/gravel braid bars, have sandy deposits while the old channels, or 'swales', have dense, whitish, fine-grained pumice silts at the surface.

On top of the sand is a layer of volcanic ash derived from eruptions in the Volcanic Plateau over the last 18,000 years. At this distance from the source it is hard to relate tephra to a particular eruptive event, though the bulk of the ash cover is considered to be part of the Rotorua Ash Formation dated at about 13,000 years[1]. However cores taken in Lake Okoroire (now drained) by scientists from Waikato University have identified 19 tephras of the last 19,000 years ranging from 10cm to a few millimetres in thickness. This ash layer is the parent material of the modern soils of the plain.

Two very different soil types have developed from this volcanic ash parent material corresponding to the micro-topography of the plain, the Waihou Soils of the sandy ridges and the Waitoa Soils of the silty swales. Both soils have developed from the same parent material, airfall tephra of the last 18,000 years.

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[1] The Rotorua Ash is a widespread (>10,000 $km^{2)}$ tephra fall deposit erupted during the extrusion of a rhyolite lava dome complex near the Lake Tikitapu Basin south-east of Rotorua. Its original thickness in the Matamata area was about 30 cm. Nairn 1980, p.193.

The Waihou soils, which make up the bulk of soil cover on the plain, have weathered under aerobic conditions, i.e. with atmospheric oxygen freely available. The tephra, which is high in volcanic glass, has weathered to form a clay mineral called allophane, which gives the soil its light, friable character and good crumb structure. Waihou soils have a low bulk density, 0.8 to 0.9[2], which allows free water and root penetration, giving a horticultural soil of the highest quality. Iron minerals occur in the insoluble ferric state, contributing to the red-brown colour of the soil.

The Waitoa soils, those of the old channels, or swales, have developed on tephra overlying a dense pumice silt deposit which impedes drainage and allows swampy conditions to occur. Weathering of the tephra has taken place under anaerobic conditions (i.e. in the absence of free atmospheric oxygen), leading to the formation of the clay mineral halloysite. The resulting soil has a high bulk density, about 1.5, and is very firm so that plant roots are unable to penetrate it except by following cracks, giving a very restricted rooting volume. In the anaerobic conditions iron minerals are in the ferrous state (grey-green colours), and in this form they are highly mobile and are washed down the soil profile until they reach aerobic conditions in the sands which underlie the silts. There they oxidise to the insoluble ferric state as an iron-rich layer of a rust-brown colour. Waitoa soils are very wet and become waterlogged, and so are restricted in the range of crops they can support. Since internal lateral movement of water is small tile drainage is not practical and surface drains must be used.

[2] Bulk density is the weight of a material divided by its volume, including the pore spaces.

THE GEOLOGY OF THE KAIMAI RANGE

The Kaimai Range, as we see it today, is the result of a long and complex history of volcanic eruptions, erosion, and modification by movements of the earth's crust along a major fault line. The range is the southern sector of the Coromandel Volcanic Zone, which includes the volcanics of the Coromandel Peninsula. Over the last two million years the active volcanic arc has migrated south-eastwards and today lies through the Taupo Volcanic Zone from Ruapehu to White Island.

The range consists of two different volcanic terrains. North of the Puketutu Stream is an area of andesite volcanism, while to the south of the Puketutu is a landscape of rhyolite volcanism, ignimbrite flows and lava domes. Along its western margin the junction with the plains of the Hauraki Depresssion is marked by an apron of alluvial fans and mass movement deposits collectively known as theGordon Formation.

1. THE KAIMAI ANDESITES

The northern part of the Kaimai Range, from Mt Te Aroha to just south of Gordon, is made up of the faulted and eroded remnants of a line of andesite volcanoes. These have been studied, mapped and described in detail by Houghton and Cuthbertson (1989). They describe three major periods of eruptive activity and a later intrusion of andesite lavas into pre-existing rocks.

(i) The Waipupu Andesite Formation

About sixteen million years ago, in the middle Miocene period, volcanic eruptions began in the Matamata district. The eruption of these andesitic lavas built up a multiple vent strato-volcano which probably resembled Ruapehu in appearance. The eruptive centres were west of the present Kaimai Range; the rocks we see in the range are part of the eastern flanks of the mountain mass, the

western parts having been carried down with the formation of the Hauraki Depression. The lavas and breccias produced in this first episode of volcanism are known as the Waipupu Formation, named for the Waipupu Stream north of Thompson's Track. They outcrop along the lower part of the range as far south as Gordon, and are assumed to overlie greywacke basement rocks.

(ii) The Uretara Andesite Formation

In time the Waipupu volcanoes were heavily eroded. In the late Miocene, about 8-10 million years ago, renewed volcanism resulted in the building of a new volcanic pile which overlapped and covered the Waipupu landscape, again giving rise to a Ruapehu-like mountain.

The rocks of this period of volcanism are known as the Uretara Formation, after the Uretara Stream which rises east of Wahine Rock and flows into the Tauranga Harbour. The Uretara Volcanics make up the upper part of the range as far south as the Puketutu Stream, and outcrop on the lower slopes south from the Barton Rd quarry. In the area between the Puketutu Stream and the quarry they are overlain by the Waitearíki Ignimbrite.

On the surface of the Uretara landscape a number of small lakes existed, and the lake-bed sediments have been preserved in places. An outcrop of these lake sediments occurs near the Barton Rd quarry. Pollen grains recovered from the sediments indicate a warm temperate climate with forests of a large-leafed species of beech.

(iii) The Pukepenga Andesite Formation

A third volcanic outbreak occurred some five million years ago, giving rise to the lava and breccia flows of the Pukepenga Formation, named for Pukepenga peak (841m) , east of Gordon.

The Pukepenga Formation makes up the high crest of the range from Ngatamahinerua to a point just south of the Kaimai Tunnel.

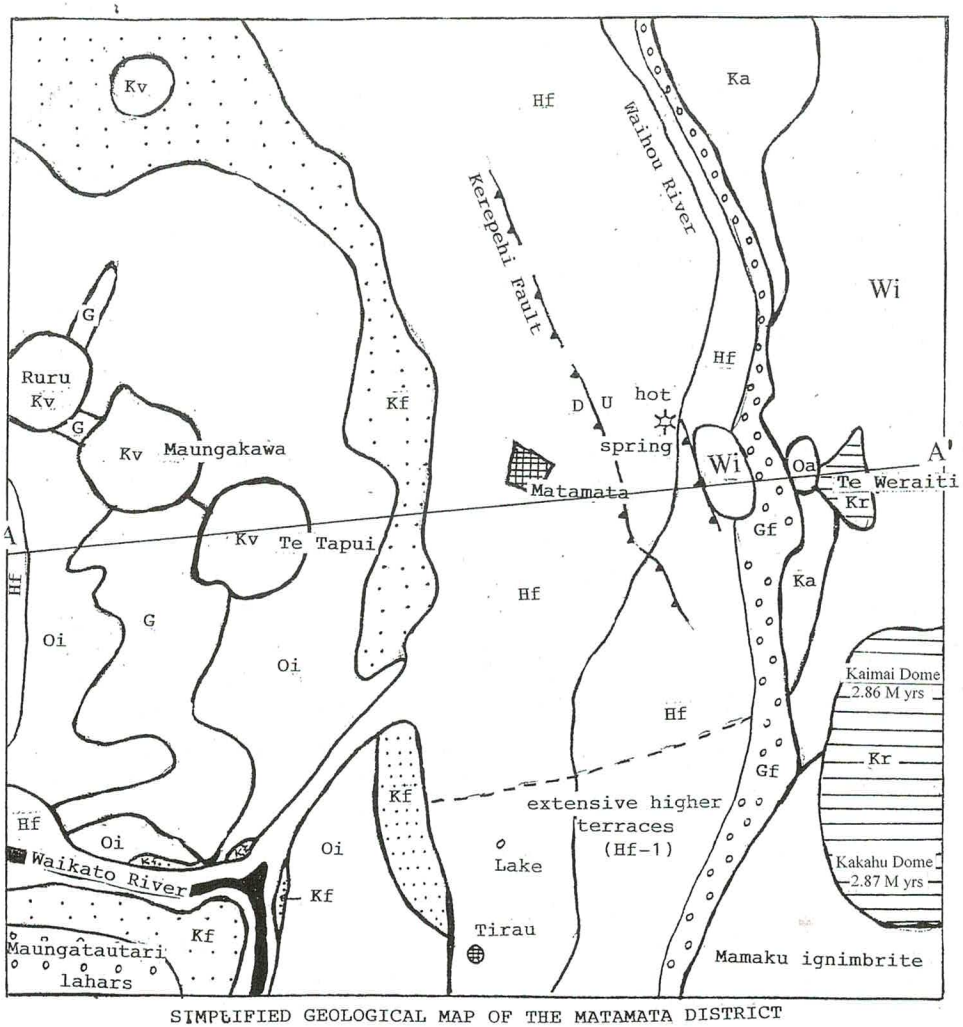
The central vents and western flanks of these volcanoes have been carried down along the Hauraki Fault and their remains now lie far below the surface of the modern landscape. The contact with the underlying greywacke may be as much as 1,400m down. Although the rocks of the Kaimai Range were formed by volcanic activity the present appearance of the range owes most to tectonic earth movements along a major fault line. Imposing though the range appears today it would have been dwarfed by its volcanic predecessors now largely demolished by the forces of erosion and tectonics over millions of years.

(iv) The Omahia Andesites

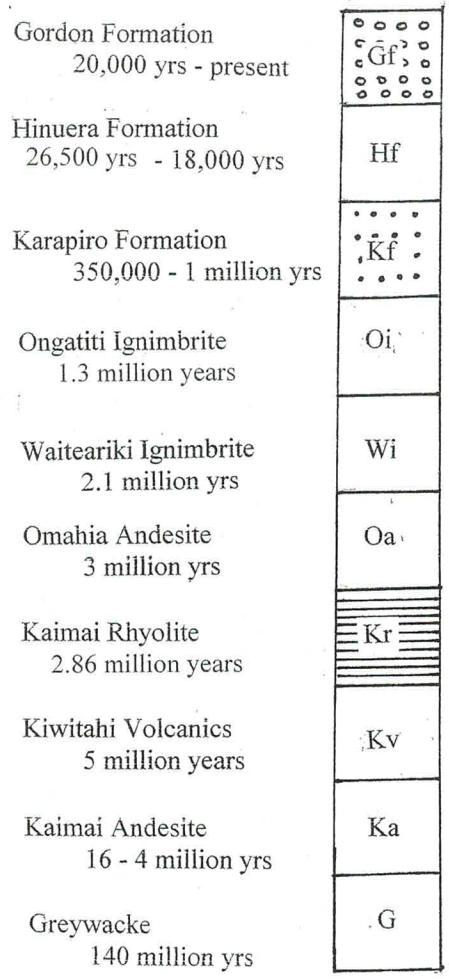
The last episode of andesite volcanism saw the emplacement of a series of lava dikes, the Omahia Andesites, which forced their way up from great depths, intruding the older rocks. The rock of one of these dikes is being quarried at Barton Rd, south-east of Matamata. The distinctive red colour of some of the rocks in the quarry is due to hydrothermal alteration of the iron minerals contained in the andesites as hot thermal waters and steam forced their way through the rocks. The Omahia Andesites have been dated at about 3 million years.

The name Omahia, though now established terminology, is probably due to an error, a mis-spelling of the name Omahine. Omahine Road and stream are located near another outcrop of this andesite two kilometres south of the Barton Rd quarry.

Andesite lavas are generally recognisable by their dark groundmass with a sprinkling of light-coloured crystals of the mineral feldspar. If you pick up a piece of road metal near Matamata there is a good chance that it will be an andesite.

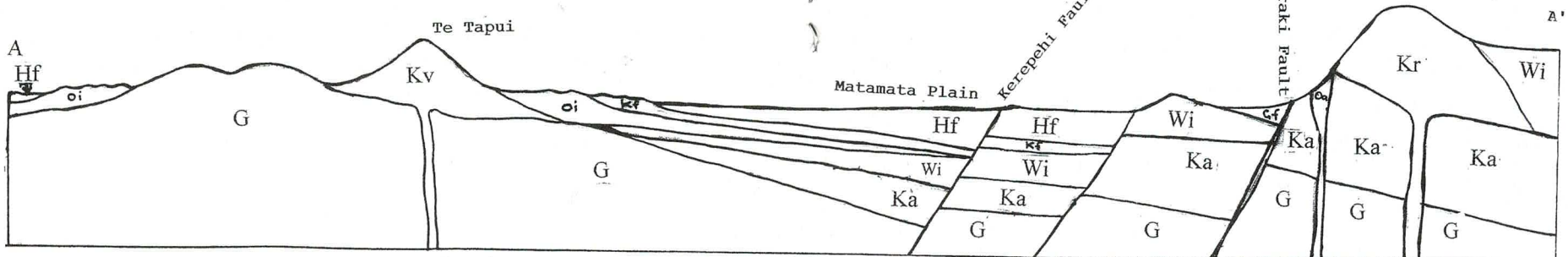


SIMPLIFIED GEOLOGICAL MAP OF THE MATAMATA DISTRICT

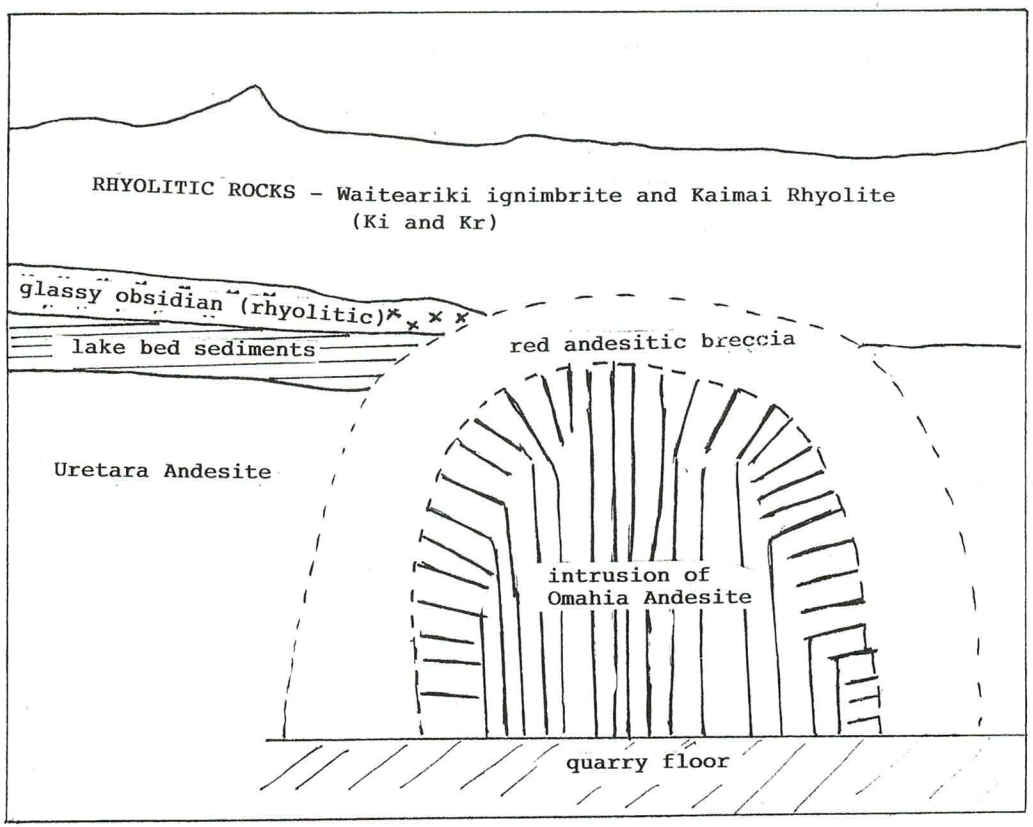


To make the map easier to follow, colour it as follows:

Greywackes (G) .....blue
Andesite volcanics (Ka,Kv, Oa)..... red
Rhyolite Volcanics (Wi, Oi, Kr, Mamaku Ignimbrite) .....orange
Fluvial sediments and mass movement deposits (Kf, Hf, Gf, Maungatautari Lahars ..... yellow



DIAGRAMMATIC SECTION ACROSS MATAMATA DISTRICT, A – A'



INTRUSION OF OMAHIA ANDESITE
AT BARTON RD QUARRY

The Omahia Andesite has intruded the older Uretara Andesite. As the intrusion of molten lava cooled shrinkage cracks developed at right angles to the cooling surface, forming the columns seen the face of the quarry.
A red-coloured envelope of hydrothermally altered breccia has been formed by the chemical alteration of the of the rock by hot volcanic fluids during and after the emplacement. The red colour is due to the oxidation of oxidation of iron minerals in the rock.
Lake bed sediments, containing a Miocene pollen assemblage, occur on the old surface of the Uretara Andesite landscape.
Later eruptions of ignimbrite and rhyolite lava flows have covered the former andesite landscape.
The glassy obsidian is due to rapid cooling of the base of the rhyolite flow.

2. THE KAIMAI RHYOLITES

South of the Puketutu Stream the appearance of the range changes to a level skyline at a lower elevation than the more varied peaks of the andesites to the north. This is the Whakamara Plateau (about 600m elevation) formed by the Waitearikiignimbrite. At its southern end the skyline rises gently to the rhyolite dome of Te Weraiti (766m).

(i) The Waitearikiignimbrite

The Waitearikiignimbrite is an extensive, large-volume ignimbrite which forms the cap of the range and underlies much of the Tauranga Basin and the southern part of the Hauraki Plains. It was erupted 2.1 million years ago in a violent caldera-forming event. The exact source is not known for certain, but it was probably near the present Kaimai summit just north of SH29 (Lowe and Newnham, 1999). The ignimbrite flowed east and west from the source, covering the southern flanks of the Uretara volcano.

It was emplaced before the uplift of the Kaimai Range. To the west of the Hauraki Fault the ignimbrite was carried down into the Hauraki Depression, where it is covered by the younger Ongatiti Ignimbrite and the alluvial deposits of the Karapiro and Hinuera Formations. . On the Kaimai block, to the east of the fault, it has been uplifted and tilted towards the north-east into the Tauranga Basin where again it is covered by younger deposits both volcanic and alluvial.

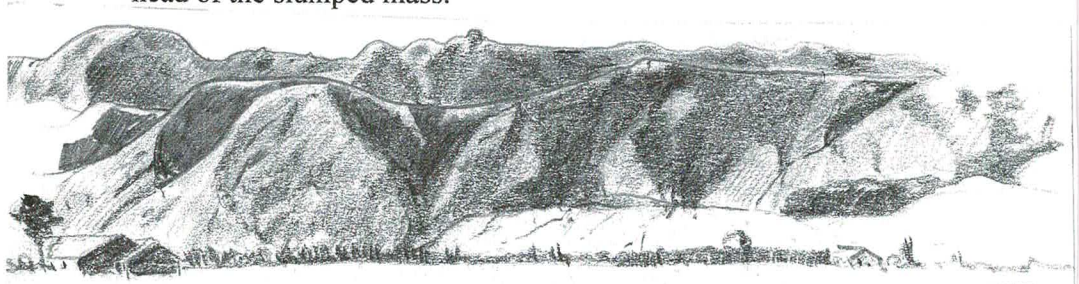
The bulk of the Waitearikiconsists of a moderately to strongly welded grey-brown ignimbrite. The upper part of the flow is softer and unwelded. It can most easily be seen at McLaren Falls and in bluffs along Kumikumi Rd on the north side of SH29 about 3 km on the Tauranga side of McLarens Falls.

(ii) Te Weraiti Rhyolite Dome

This is one of a number of rhyolite domes in the Kaimai-Tauranga area. Rhyolite domes are the product of non-explosive extrusion of viscous rhyolite lava which accumulates over the vent. They are commonly associated with the margins of calderas produced by ignimbrite eruptions. Examples are Mt Maunganui and, further afield, Ngongotaha and the multiple domes of Tarawera.

3. THE GORDON FORMATION

At the break of slope along the western margin of the range, where it meets the plains of the Hauraki Depression, is an apron of alluvial fans and slumps (mass movement deposits). The mouth of every stream where it leaves its steep gorge section and passes on to the plain is marked by an alluvial fan. In other places there are quite large areas of hummocky ground caused by large-scale slumps which have developed on the volcanic rocks. Most of the slumps are related to chemical alteration of the volcanic rocks of the Waipupu Formation by hot thermal waters, a process known as hydrothermal alteration. This produces weak layers which act as slide planes for the overlying rock mass. The biggest of these features is about a kilometre south of the Tuahu Track near the Waipupu Stream. it is 2.6km long and 1.4 km wide. The three small Tuahu lakes have formed behind the back-tilted slope at the head of the slumped mass.



Kaimai Range from Stanley Landing
The skyline is formed by the andesites of the Pukepenga Formation while the foreground ridge is composed of the Uretara Formation andesites. At the foot of the scarp are fans and mass movement deposits of the Gordon Formation.

VOLCANIC ASH BEDS (TEPHRAS) IN THE MATAMATA DISTRICT

Tephra may be defined as any material thrown into the air during a volcanic eruption and landing on the surrounding country. Tephra may include boulders, gravel-sized scoria (lapilli) and fine material (ash). Fine-grained tephra may be carried to heights of several kilometres into the atmosphere and may be dispersed over a wide area by winds prevailing at the time of the eruption., even circling the globe. After the Taupo eruption 1800 years ago brilliant sunsets in the northern hemisphere have been ascribed to the presence of Taupo tephra in the upper atmosphere.

Tephras falling on to a land surface are subject to erosion and weathering , so that in time they are either washed off into rivers or become incorporated in the soil. Nevertheless a series of recognisable ash beds can accumulate over time, and on older surfaces a long succession of tephras may be seen, each telling the story of a particular eruption.

Especially good sites for ash bed preservation are lake beds. The ash settles quietly on the lake bed. In time it is covered by lake muds before the next tephra comes in. In the quiet, undisturbed lake environment the layers are preserved and can be studied in cores of sediment taken from the lake bed. Scientists from the School of Earth Sciences at Waikato University have pioneered this technique and have studied ash sequences from many Waikato and Thames Valley lakes and peat swamps.

Even better for tephra preservation is the deep sea. In 1999 a hole drilled 600 km east of the North Island coast as part of the international Ocean Drilling Programme produced a core 474 metres long which included 141 individual layers of volcanic ash up to 0.9 metres thick. The oldest ash accumulated about 11 million years ago. These tephras represent huge rhyolitic eruptions in the Coromandel and Taupo Volcanic Zones, and give a continuous record of volcanism in New Zealand. (Carter et al,

1999) . Many other ocean drill holes have provided important tephra records.

Because the age of tephras can be determined using radiometric techniques, they provide invaluable time markers in any depositional sequence in which they occur.

On the land surface a soil will eventually develop on a tephra layer, only to be buried, perhaps centuries later, by the next tephra fall. The buried soil, or 'paleosol' (ancient soil) can still be recognised as such by its structure and colour, and in a section which contains a number of tephra layers the paleosols help the geologist to separate one tephra from another.

Look in road cuttings on the older surfaces (Karapiro Formation and older) for the distinctive layers which represent a series of tephras. Examples are to be seen at the corner of Lansdowne and Kirk Roads, on the Te Poi-Tapapa road about a kilometre north of the Okoroire Hall, along Taotaoroa Road and along the Old Te Aroha Road between Okauia and SH29. On these older surfaces cover beds, mainly tephras but probably including some loess deposits as well, may be up to three metres in thickness, while on the much younger Hinuera Surface tephra cover is about 0.8 metres near Matamata, thinning rapidly northwards to only about 10cm at Ngarua.

Further afield, excellent tephra sections can be seen near Rotorua and on the Desert Road.

While it is fairly easy to recognise a tephra succession for what it is, more detailed study is not so simple, especially at sites a considerable distance from the eruption vent. A few tephras have a distinctive appearance which is easily recognised, and therefore called 'marker beds' because they provide a datum of known age in a succession of beds which may be more difficult to identify. A prominent marker bed is the Rotoehu Tephra, which can often be seen as a distinct light-coloured layer in roadside cuttings. The Rotoehu Tephra was erupted near Rotorua and is dated at 64,000 years B P (before present).

The oldest tephra sequence in our area is the **Kauroa Ash Formation,** or 'K Beds'. This comprises up to 12 metres of extremely weathered tephra beds, made up of at least 15 separate ash layers. The oldest is about 2.25 million years old, and may have come from the eruption which produced the Waitetariki Ignimbrite, while a tephra dated at about 1.2 million years is likely to be the airfall component of the Ongatiti Ignimbrite eruption. Because the K Beds are so old they can be seen only on the greywacke surfaces, e.g. along Taotaoroa Rd.

Younger than the Kauroa Formation is the **Hamilton Ash Formation**[3] , which consists of up to six metres of strongly weathered tephra beds. The oldest of these is the Rangitawa Tephra, dated at 350,000 years and considered to be the airfall part of the Whakamaru ignimbrite eruptions (Lowe et al, 1999). It is a distinctive, dense, light-coloured bed overlying the dark red-brown upper member of the K Beds. In the Matamata district the Hamilton Ash Formation can be seen on the Karapiro Formation surfaces and older.

Overlying the youngest of the Hamilton tephras is the **Rotoehu Ash**, about 64,000 years old, and above this a succession of younger tephras, not always individually identifiable, culminating in the Matamata area in a few small pumice fragments representing the Taupo eruption of 1800 years ago.

The **Rotorua Ash** mantles the Hinuera Surface on the Matamata Plain and is the parent material of the present-day soils. It is also part of the ash cover on older surfaces. It was erupted from the Okataina Volcanic Centre about 15,800 years ago in an event which produced about 7 km^3 of airfall material.

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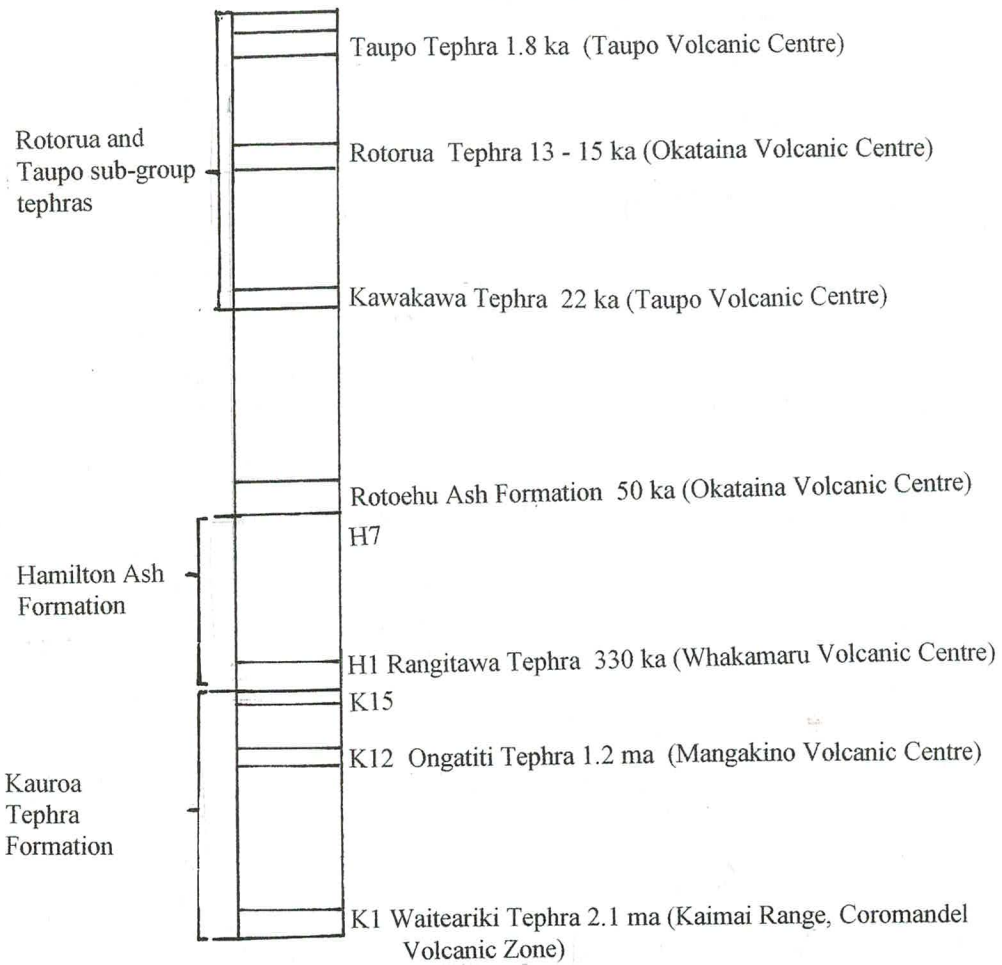
[3] Because tephras were studied in the field before their sources had been identified, and also because a tephra formation may contain ash beds from a number of sources, they are usually named for the place where they were first studied and described. Thus the Hamilton Ash Formation is so named because its description is based on a section near Hamilton, though the source of the ash beds was in the Volcanic Plateau.

During the 1950s a sprinkling of ash from an eruption of Ngaruahoe fell on Matamata and could be seen as a dusting on parked cars and other surfaces; this would have left no trace in the geological record.

SOME IMPORTANT TEPHRAS


Taupo Tephra 1.8 ka (Taupo Volcanic Centre)
Rotorua and Taupo sub-group tephras
Rotorua Tephra 13 - 15 ka (Okataina Volcanic Centre)
Kawakawa Tephra 22 ka (Taupo Volcanic Centre)
Rotoehu Ash Formation 50 ka (Okataina Volcanic Centre)
H7
Hamilton Ash Formation
H1 Rangitawa Tephra 330 ka (Whakamaru Volcanic Centre)
K15
K12 Ongatiti Tephra 1.2 ma (Mangakino Volcanic Centre)
Kauroa Tephra Formation
K1 Waitearikí Tephra 2.1 ma (Kaimai Range, Coromandel Volcanic Zone)

This diagrammatic representation of the tephra column shows only a few of the more important tephras of the last 2 million years.
Drillhole 1124 on leg 181 of the International Ocean Drilling Programme, 600 km east of Hawkes Bay, showed the presence of 141 layers of volcanic ash accumulated since about 11 million years ago. Individual ash layers were up to 0.9m thick, indicating the very large scale of some of the eruptions represented.

GEOLOGY AND EVERYDAY LIFE

Geology is not just an abstract concept but something which affects all of us every day of our lives. The landscape in which we live is the product of geological processes. The landforms and the rocks of which they are composed, influence our daily lives in a multitude of ways.

Rock - a vital resource

The quarrying of rock from both the greywackes and the andesites produces crushed rock, essential in many ways. Every time you walk on a footpath, drive on a road or enter a concrete building you are making use of quarried rock. The Barton Rd quarry produces 90,000 cubic metres of crushed andesite a year and the Taotaoroa Rd 50,000 cubic metres of greywacke. The Ongatiti Ignimbrite is quarried for building stone and the Hinuera Formation for fill, for aggregate (22,000 cubic metres were used in constructing the Kaimai Tunnel), and for horticultural products such as potting mix. It has been estimated that in these and other ways each person uses 20 tonnes of rock a year to provide resources. Glass, roofing steel, structural steel as aluminium are all products derived from mineral raw materials.

Minerals

The combination of volcanic activity and faulting has given rise to epithermal mineral deposits, notably gold and the sulphides of iron (pyrite), lead (galena) and zinc (sphalerite). These minerals do not occur in the Matamata district, but gold mining was carried on, with little success, in the Waiorongomai Valley during the 1880s and for several years lead was mined at the Tui mine near Te Aroha . The same processes have been responsible for the very productive Martha Mine at Waihi.

Climate

The uplifted Kaimai Range affects the climate of our area. Its orientation at right angles to the prevailing westerly winds contributes to the high rainfall which makes it an important catchment area, the source of many streams as well as the Matamata urban water supply. Local effects include the strong winds which sometimes funnel along the western face of the range, the 'Kaimai buster', the updraughts which make Matamata a favoured venue for gliding, hang gliding and parapenting, and the cold air drainage on to the plain which contributes to heavy frosts in winter.

In the western hills the fact that the area is largely above the frost line contributes to the importance of orcharding in the Peria district near Matamata.

Vegetation and Recreation

The forest cover on the steeper slopes and higher elevations is essential for erosion control. The forests of the Kaimai Range at one time supported a timber industry but are now part of the Kaimai-Mamaku Forest Park, an important recreation area with some 200 km of walking tracks. The most popular attraction is the Wairere waterfall. Bush on the higher slopes of Te Tapui and Maungakawa is also classified a scenic reserve, though the track system is not extensive.

Communications

The Kaimai Range is a significant barrier to communications. No road crosses it between the Waihi Gorge and the Tauranga highway south of Matamata . The foot tracks over the range have historic importance, especially the Wairere Track which was used by Maori travellers in pre-European times and was for many years the main route for missionaries, traders, scientists and other travellers between the Thames Valley and the Bay of Plenty.

The Kaimai tunnel has provided a more direct rail route between the Waikato and the port of Tauranga at a cost of many millions of dollars but with big savings in operational and maintenance costs compared with the former route through the Waihi Gorge. High points on the Kaimai Range are ideal sites for TV and telecommunications masts and air navigation beacons,

The western hills are a lesser but still significant barrier to communications between Matamata and the Hamilton Basin. Avoidance of hill country by major routes adds about 15 km to a journey from Matamata to Hamilton compared with the straight line distance. Again, a high point (Ruru) is used for a a TV mast.

The Hinuera Valley, cut by the Waikato River through the ignimbrite sheet, is also a significant communications feature. In earlier times it was an important routeway linking the Waikato River to the Bay of Plenty via the Wairere Track over the Kaimai Range. Not far away, at Horahora, was the Aniwaniwa crossing of the Waikato River from which trails led to Maungatautari, the Waipa Valley, south to Waotu and east to Rotorua. Lining the valley a series of terraced pa sites can still be seen. Today the busy SH29 leads east to Tauranga and north via Matamata and SH27 to Auckland.

Hot Springs

At the foot of the Kaimai Range the hot springs associated with the Okauia Fault are an important tourist attraction. Hot springs in the Matamata district are associated with faulting and so are known as tectonic hot springs. Surface water percolates downward along the crush zone of a fault and is heated by the normal thermal gradient of the earth, about 30^0 C per kilometre. After heating the water ascends to the surface as a hot spring. Temperature and mineral content in tectonic hot springs are generally lower than in springs associated with true hydrothermal systems such as those found at Rotorua. The best known hot

springs near Matamata are the Opal Springs at Okauia. There are also minor springs along the Kerepehi Fault.

Soils

The steep, erosion-prone slopes of the Kaimai Range have only thin skeletal soils but the easier slopes, especially on the western hills, have a thick layer of tephras on which the modern soils have developed, while on the Matamata Plain light, highly productive soils have formed on the layer of ash of post-glacial age which overlies the free-draining Hinuera sands.

GEOLOGICAL HAZARDS

Flooding

Since the end of the Last Glaciation, about 15,000 years ago, the rivers of the Matamata district have been downcutting until they now occupy valleys incised well below the surface of the plain. Consequently the risk of flooding is low, apart from minor surface flooding after heavy rain.

Earthquake

Our most prominent landform feature, the steep western face of the Kaimai Range, owes its character to the Hauraki Fault. However evidence suggests that this fault has not moved in the last 225,000 years.

Less prominent in the landscape but more recently active (within the last few thousand years), is the Kerepehi Fault, and it is likely that most past and future earthquakes felt in the district are associated with this fault. Local earthquakes in historic times have been magnitude 5 or less on the Richter scale; the zone of big earthquakes, magnitude 7 and up, is east of the Matamata district nearer the area where the Pacific plate is being subducted beneath the Australian plate. While it seems likely that this will be the pattern in the future there can be no doubt that the Kerepehi Fault is still active and could be the site of a significant earthquake event.

Volcanic eruption

The most recent volcanic activity in the Matamata district itself was the eruption of Maungatautari nearly two million years ago. A renewal of activity in our immediate neighbourhood is most unlikely.

However, Matamata is less than 100 km from New Zealand's largest and most active volcano, Taupo. Within the last 26,000 years there have been some 28 eruptions of the Taupo volcano, some very large, some quite small. The great Taupo eruption of

1800 years ago was the largest eruption anywhere on earth in the last 5,000 years. The ash layer from this eruption is five metres thick immediately east of Lake Taupo and 15 cm thick at Gisborne. An associated large, non-welded ignimbrite covered 20,000 km^2 of the central North Island. An even larger eruption took place 22,000 years ago, producing at least 800 km^3 of eruptive material including a non-welded ignimbrite and a huge volume of ash, some of which reached the Chatham Islands.

Further eruptions of the Taupo volcano are highly likely, though it is impossible to predict the timing or the size of a future eruption. It could be a big ignimbrite producer or a small dome-building event. An eruption on the scale of the one of 1800 years ago would have a devastating effect on most of the North Island. Depending on the style of the eruption and the wind direction at the time, Matamata could be affected by a heavy ash fall, or even by an ignimbrite flow. While there is nothing to suggest that such an eruption is likely to occur in the near future, the chances are that it will happen - sometime.

Recent work in the Auckland city area has revealed tephra beds ranging from 10 to 600 mm thick originating in the Taupo Volcanic Zone. Ash falls of this size could have effects ranging from respiratory problems to disruption of water supplies, death and injury from building collapse and destruction of trees, crops and livestock. In June 1996 a quite small eruption of Ruapehu caused the closure of Auckland International Airport over a period of several days. (Newnham et al, 1999).

Even closer than Taupo is the Okataina Volcanic Centre, which has erupted nearly 1000 km^3 of material in its 260,000 year history, including large ignimbrites (Matahina and Kaingaroa). Over the last 20,000 years eruptions have been smaller, building the dome complexes of Haroharo and Tarawera, the last and smallest being the 1886 eruption of Tarawera.

WINDSCREEN GEOLOGY
GEOLOGICAL TOURS IN THE MATAMATA DISTRICT

Tour 1: Alluvial plain; ignimbrites, greywackes and older alluvial terraces of the Western Downland and Hills; Hinuera Valley, Hinuera disjunction; Lake Karapiro/Waikato River; Taotaoroa Rd, Matai Rd. (See map inside front cover)

km

0 Matamata Information Centre, Broadway. Set your trip meter to 0. Cross the railway and turn left into Firth St. Continue past Matamata College. Continue on into Hinuera Rd W. Travel across the Hinuera Surface. Note the undulating surface corresponding to braid bars and channels of the alluvial fan of the Hinuera Formation.

4.7 Pass entrance to Dalton's sand quarry, working the sands and gravels of the Hinuera Formation.

6.3 Intersection of Hinuera Rd and Hopkins Rd. Note valley of the Waitoa River to the right, occupying a Last Glaciation channel of the Waikato River.

13.0 Corner of Taotaoroa Rd. Sandpit to the right has a good section through the Hinuera Formation.
Enter the Hinuera Valley, cut by the Waikato River after the emplacement of the Ongatiti Ignimbrite sheet, Note columns in the bluffs of Ongatiti Ignimbrite on either side of the valley, resulting from weathering of joints formed in the ignimbrite as it cooled.
Ahead is a good view of Maungatautari volcano (1.8 million years).

15.7 Pass entry to Hinuera Stone Quarry.

18.7 Turn right on to SH1. This is the Hinuera Disjunction, the point at which the Waikato repeatedly switched courses between the Hamilton Basin and the Hauraki Depression during periods of alluvial deposition.

The Waikato and its tributaries have cut deeply into both Karapiro and Hinuera sediments in inter- and post-glacial periods and are now well below the Hinuera Surface. Prior to the filling of Lake Karapiro the river flowed in a deep gorge.

The bluff straight ahead (below house) is composed of . gravels of the Karapiro Formation.

Leave the Hinuera Surface and descend to travel beside Lake Karapiro.

21.1 On the right is an outcrop of greywacke of Jurassic age (not easily seen as it is rather overgrown).

21.6 The high cutting on the right is in gravels of the Karapiro Formation. Because the Karapiro Formation is older and more consolidated than the Hinuera it can support steeper slopes which would not be stable in Hinuera Formation sands.

24.5 Rest Area on left. **STOP**. View of lake and surrounding area. The bluffs on the opposite side of the lake are in Karapiro Formation gravels. There is a good view of terraces cut by the Waikato River in the post-glacial period, the last 15,000 years.

Down the lake (west) the skyline is formed by greywacke hills, while the up-lake (east) skyline is the Ongatiti Ignimbrite sheet.

Return along SH1,* ascend the hill on to the Hinuera Surface and turn left on to SH29.

Carry on to the **Piarere Hall** on left. **STOP.**

From here many features of geological interest can be seen (see figs 1 and 2, p 58).

(1) The Karapiro Terrace, a high alluvial terrace of the Karapiro Formation, a set of alluvial gravels more than 350,000 years old.

(2) Maungatautari volcano, an andesite volcano active about1.8 million years ago, rising above the ignimbrite sheet,

* From this point a diversion could be taken to the Horahora Domain (fig.3 p59) This has not been allowed for in the distance readings on the itinerary.

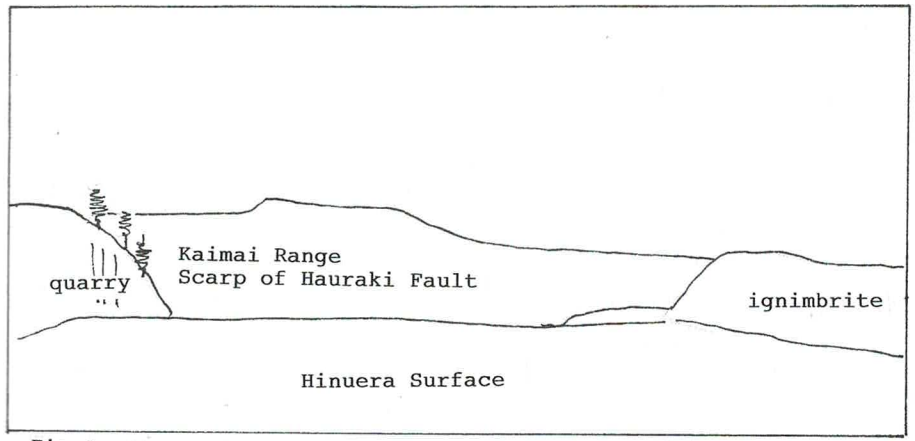


Fig.1 - From Piarere Hall looking North-east

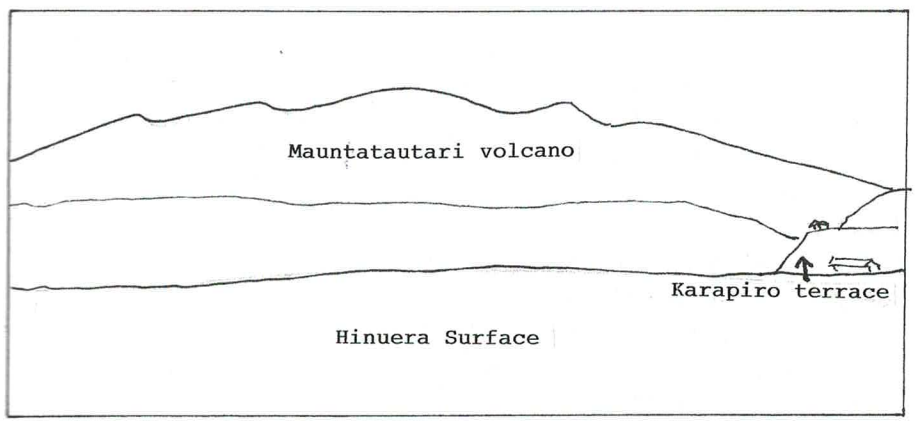


Fig.2 - From Piarere Hall looking West

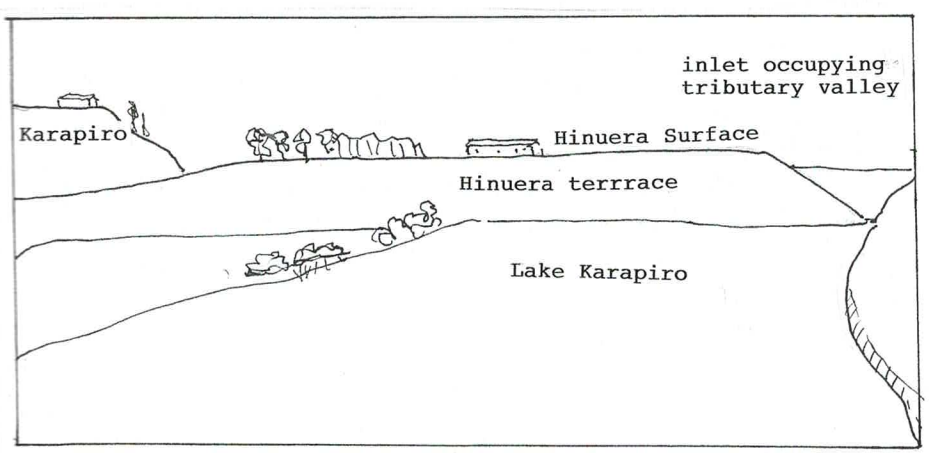


Fig. 3 - From Horahora Domain looking north

which flowed around it like a flood as it buried the lower parts of the landscape.

(3) Bluffs of Ongatiti Ignimbrite and the Hinuera Stone Quarry. Note terraced pa sites on the ignimbrite surface. The bluffs above the break of slope represent the Ahuroa Ignimbrite.

(4) The Hinuera Surface stretching away to the north to form the extensive Matamata Plain.

(5) The Kaimai Range and the scarp of the Hauraki Fault. Note the level skyline of the Waiteriki Ignimbrite and the rise to the rhyolite dome of Te Weraiti.

(6) The importance of the Hinuera Valley. In Maori and early European times it was a major routeway from the Waikato over the Kaimai Range via the Wairere Track, the location of which was marked by the prominent landmark of the Wairere Falls. Today it is still a major routeway linking SH1 to Tauranga and Auckland via SH29 and SH27 respectively.

36.3 Crossroads. Turn left into Taotaoroa Rd.

37.0 Rise on to the ignimbrite landscape and soon descend into the valley of the Mangawhea Stream which has cut deeply into the ignimbrite, exposing high bluffs at intervals along the western side of the valley.

42.0 Rise on to the upper surface of the ignimbrite and soon rise again on to the greywacke hills. Cuttings on these older surfaces show exposures of the volcanic ash cover, in which fossil soils (paleosols) can be seen marking the breaks between individual tephras.

43.5 Pass the entrance to the Taotaoroa Quarry. Continue over the crest of the hill and commence descent.

45.0 Turn in farm gateway on left and return to top of hill.

45.2 Top of hill. Cutting on right contains a 6m section of volcanic ash beds. Two-thirds of the way up the section is a light-coloured bed that represents the Rotoehu Ash (part of

the Rotoiti Tephra Formation) dated at 64,000 years BP. Below it is a well-developed dark-coloured paleosol. This represents a surface on which soil development had gone on for a long time before it was buried by the Rotoehu Ash. The Rotoehu is an easily recognised marker bed over a large part of the North Island. It originated in an eruption near Rotorua. Below it are the ash beds of the Hamilton Ash Formation, underlain in turn by the Kauroa Ash Formation. Above it are younger tephras, the product of eruptions in the central Volcanic Plateau.

Unfortunately this section is overgrown with grass and bushes and it is difficult to see its features.

46.3 **STOP** at quarry entrance. To the north is a good view of the greywacke landscape and of the quarry, which is working the greywacke. Beyond the quarry is a dissected ignimbrite landscape (note accordant summit levels, representing the original surface of the ignimbrite sheet). On the skyline is Te Tapui (Kiwitahi Andesites). Cross the road and look east across the valley to the Ongatiti/Ahuroa ignimbrite surface, with the edge of the Mamaku Plateau (Mamaku Ignimbrite) on the skyline.

By walking 50m along the road a cutting showing the light-coloured Rotoehu Ash and underlying paleosol may be inspected.

Now that you are familiar with the appearance of the Rotoehu you will be able to recognise it in many cuttings on your return trip.

53.6 Turn left on to SH29. You are now back on the Hinuera Surface.

57.3 Turn left into Puketutu Rd.

58.5 Pass Buckland Rd on left. A drive along Buckland Rd is worth while for attractive scenery with good views of ignimbrite and greywacke landscapes and thick tephra sequences.

59.1 Leave the Hinuera Surface and rise on to the Karapiro Surface. Note tephras in cutting on left.
59.8 To the left note the somewhat higher ignimbrite surface in the middle distance, with Te Tapui (Kiwitahi Andesites) on the skyline.
60.9 Turn left into Matai Rd, still on the Karapiro Surface. This surface is much older and therefore much more dissected than the Hinuera Surface.
64.2 Turn right into Station Rd.
65.9 Cross Waitoa River and return to the Hinuera Surface. Continue to Matamata urban area.

Tour 2: The eastern plain and the Kaimai Range: Tower Rd, Old Te Aroha Rd, Wardville Rd, Gunn Rd. (See map)

km

0 Information Office, Broadway.
Travel east along Broadway.
Turn left into Tower Rd. Travel across the Hinuera Surface.
3.6 Cross a former river channel and ascend the scarp of the Kerepehi Fault (Tower Hill). Note Firth Tower Museum on right.
4.7 Turn right into Springs Rd.
6.4 To the right is a view of the scarp of the Okauia Fault forming the steep western scarp of a prominent hill, a downfaulted block of Waitearíki Ignimbrite, in the middle distance. Beyond is the steep scarp of the Hauraki Fault rising to a level crestline that owes its character to the Waiteriki Ignimbrite. On the face of the scarp is the large Barton Rd quarry working an intrusion of Omahia Andesite. On top of the range to the right of the quarry is the rhyolite dome of Te Weraite (756m).
6.9 Pass Matamata Golf Course and descend into the entrenched valley of the Waihou River. Note Okauia (Opal) tectonic hot springs on the left, on the Okauia Fault.

8.5 Okauia Hall. From here there is a good view of fans and mass movement deposits of the Gordon Formation along the foot of the scarp, and a closer view of the Barton Rd quarry.
8.6 Turn left into Old Te Aroha Rd.
12.2 Descend to cross stream. Current bedded alluvium in cutting.
12.3 Pass Tills Rd. At the top of the road the buildings of the Matamata water supply can just be seen, a reminder of the importance of the range as a water catchment area.
To the left the Waihou River has, in post-glacial times, cut down to become entrenched below the Hinuera Surface.
13.3 Graveson Rd. View of Wairere Falls.
13.9 STOP opposite gate in hedge. View of Wairere Falls. Note the deep gorge formed downstream of the falls as they have retreated upstream. On top of the range the stream flows over the Waitearíki Ignimbrite. The rocks exposed in the falls and the gorge are the underlying Uretara Andesites. The historic Wairere Track ascended the ridge to the right of the falls. It was used by Maori, by explorers such as Colenso and Hochstetter, and by missionaries and traders as a major route linking Matamata to the Bay of Plenty. The modern track follows the true right bank of the stream and joins the old Wairere Track further up.
14.9 Pass Goodwin Rd, access to Wairere Falls Scenic Reserve.
17.4 The Puketutu Stream emerges from a spectacular gorge. The stream has followed a line of weakness in the rock, an old brecciated lava flow with some hydrothermal alteration.
18.3 Pass under the overbridge of the railway line leading to the Kaimai Tunnel. On the western side of the range the tunnel passes through the Uretara Andesite. The Jarva tunnelling machine was unable to deal with this hard, jointed rock. It was moved to the eastern portal where it was ideally suited to the Aongotete and Waitearíki Ignimbrites encountered in the eastern 4 km of the tunnel.

20.4 Gordon. The dome-shaped summit of the range is Ngatamahinerua (848m). From here south for about 4 km the crest of the range is formed by the Pukepenga Andesites, the youngest of the three main andesite formation of the Kaimai Volcanics.
Turn left into Wardville Rd.

21.1 Cross the Waihou River. Flats on the river banks are the sands and gravels of the Waitoa Alluvium, the youngest of the river deposits in the district. A few hundred metres upstream is Stanley Landing (named by J C Firth for H M Stanley, the African explorer) which was the head of navigation for Firth's river steamer the *Kotuku* about 1880.
Pass through the crossroads and continue west along Wardville Rd over the Hinuera Surface.

24.5 Pass Waghorn Rd to right.

26.8 Pass Alexandra Rd. Immediately before the small bridge over the Waihekau Stream cross the low scarp of the Kerepehi Fault, at the foot of which are more Recent Waitoa Formation sediments.
Turn left on to SH27.

31.5 Pass through Waharoa township, cross railway line. Almost immediately turn right and then left into Landsdowne Rd.

33.4 Cross Waitoa River. Waitoa Alluvium alongside river.

34.0 Turn left into Gunn Rd.

35.3 Leave the Hinuera Surface and rise on to a terrace of the Karapiro Formation gravels. Small road cuts show a covering of volcanic ash beds.

36.5 Cutting on right shows volcanic ash beds.

36.9 Cross a small bridge and return to the Hinuera Surface.

37.9 Turn left into Peria Rd. Soon cross the Waitoa River, occupying a former channel of the Waikato River. Return to Matamata on the Hinuera Surface. Note slight undulations corresponding to former braid bars and channels of the braided river system of the Last Glaciation.

3. Tour 3: A View From the Top - The Kaimai Lookout

From the lookout near the summit of the range on SH29 many geological features of the Matamata district and beyond can be seen. Refer to the accompanying diagram.

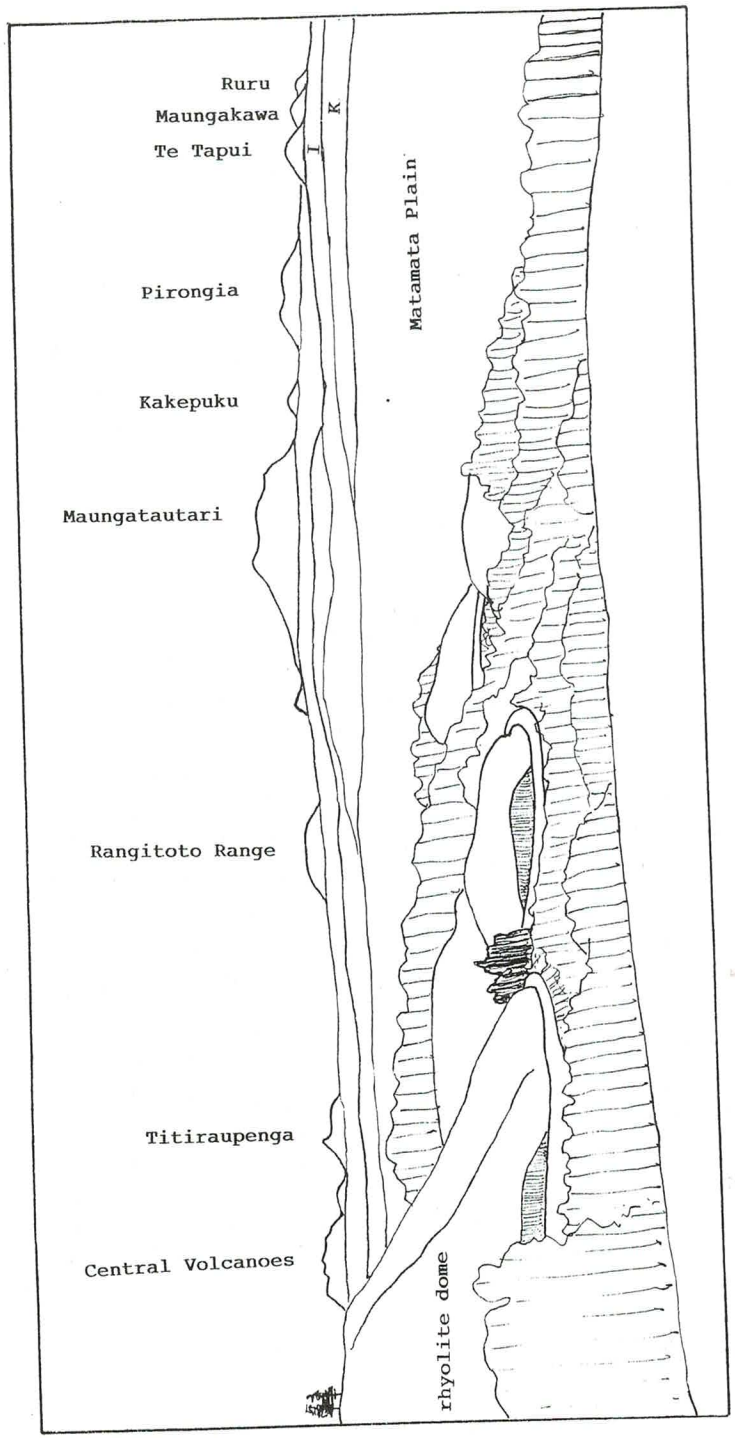
(i) The Hauraki Fault Scarp and the Hauraki Depression: The lookout is located on the edge of the Hauraki Fault Scarp at approximately 400m above sea level, and looks out over the Hauraki Depression, some 300m below, filled with the alluvial sands and gravels of the Hinuera Formation. The scarp stretches away to the north, separating the uplifted Kaimai block from the downthrown Matamata Plain.

(2) Rhyolite domes: The rocks exposed in the roadside cutting are rhyolites on the northern edge of a large (15 x 10 km) rhyolite dome. Note the creamy-white colour of the rhyolite. North of the road the crest of the range rises to the Te Weraiti rhyolite dome.

3. The Kiwitahi Volcanics, the Karapiro Formation alluvial terraces and the Ongatiti Ignimbrite. On the far side of the Depression are the three small volcanic remnants of Te Tapui (492 m), Maungakawa (495m) and Ruru (482m), which are the southern and youngest members of the Kiwitahi Volcanics. In front of the volcanoes are two surfaces slightly higher than the Matamata Plain which is here about 80m above sea level. These make up the downland developed on the Ongatiti Ignimbrite and the Karapiro Alluvium at 100 to 200 m. a.s.l.

4. Greywacke hills and ranges: In the distance is the Rangitoto Range, part of a line of greywacke hill country on the western edge of the volcanic plateau and extending north through the Matamata district into the Hunua Hills south-east of Auckland. The greywackes of the Taotaoroa-Whitehall area can be seen at a higher level than the Ongatiti Ignimbrite.

5. Maungatautari: An andesite composite volcano built up by a series of eruptions from several centres over a period of thousands of years. Lavas from Maungatautari have been dated at 1.8 million



FEATURES OF GEOLOGICAL INTEREST VISIBLE FROM KAIMAI LOOKOUT NEAR MATAMATA

years. The eroded cone is 797m a.s.l. and about 8km across at the base.

6. Pirongia: In the far distance can be seen two other old andesite volcanic peaks, Pirongia and Kakepuku on the western side of the Waikato basin. These are dated at about 2.5 - 3 million years and they too are heavily eroded.

7. Titiraupenga: This is another deeply eroded andesitic volcanic remnant.

8. The Central Volcanoes - Ruapehu, Tongariro and Ngauruhoe. These volcanoes mark the southern end of the TVZ. The group is dominated by Ruapehu (2797m), which first erupted about 200,000 years ago and is still active, the last major activity being in 1996. Tongariro is a composite volcano built from the overlapping products of at least six early cones (275,000 to 65,000 years) and 11 vents younger than 25,000 years.

Ngauruhoe cone (2787m a.s.l.) is about 10,000 years old.

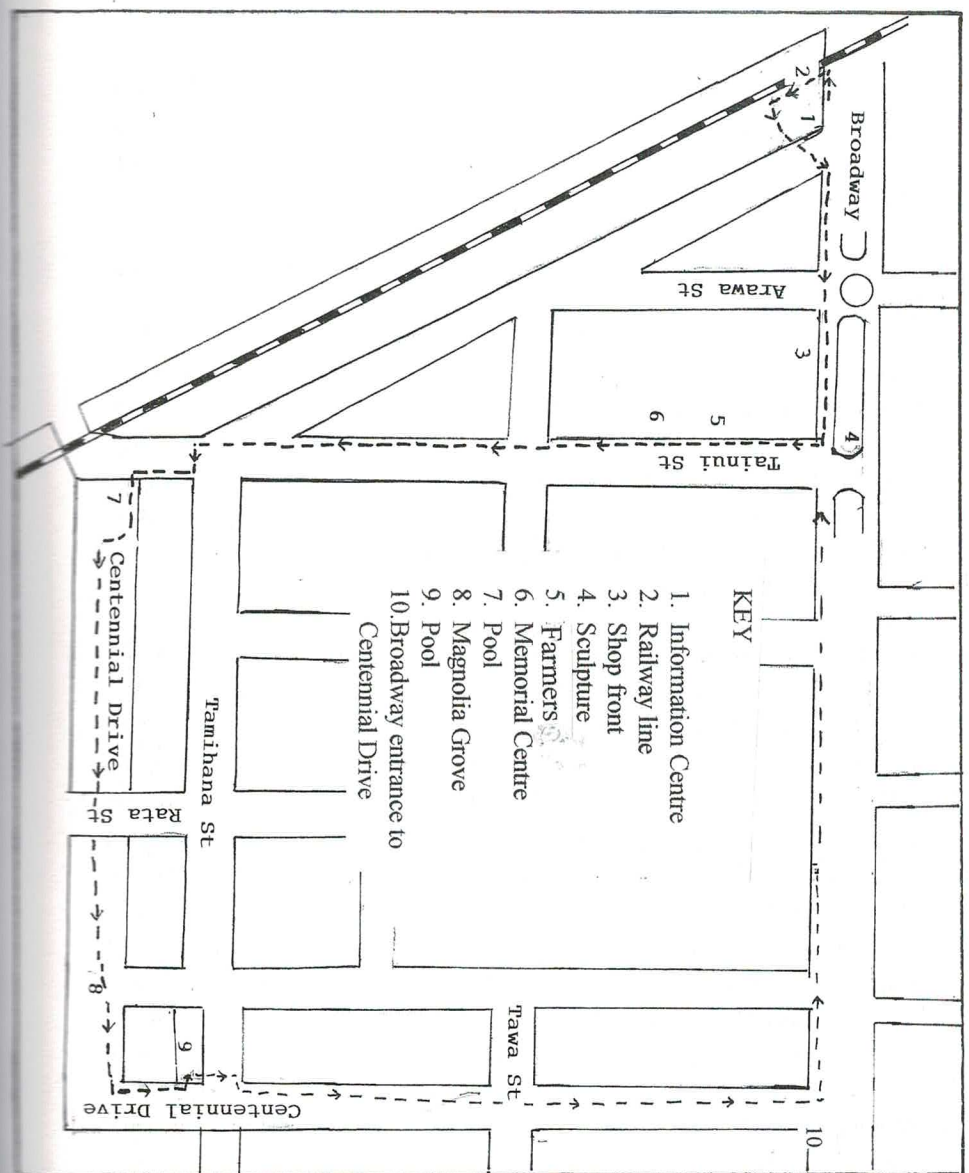
URBAN GEOLOGY

A GEOLOGICAL WALK THROUGH DOWNTOWN MATAMATA

START: Information Office, Broadway (1).
The Information Office is made of cut blocks of Hinuera Stone (Ongatiti Ignimbrite). Most of the blocks are from the middle densely welded flow unit and contain flattened pumices and some lithics. The blocks have been turned in the building process; the long axis of the flattened pumices was originally horizontal.

Walk west to the railway line (2). The ballast (rock fill used on the track) consists of fragments of Omahia Andesite from the Barton Rd quarry. At one time basalt rock from the Auckland volcanic field was used as ballast, and if you walk beside the track towards the old railway station you will find some, a dark-coloured rock with many vesicles (holes formed by gas escaping from the fluid lava during the eruption).

Return to Broadway and walk east along the south side of the street. The paving blocks of the footpath are a geological product. Cement is made by mixing lime (obtained from limestone), silica and alumina in the correct proportions. Alumina is found in clay, and the clay often contains silica as well. This, together with a silica impurity in the limestone, may be enough to give the right mix. If not, silica sand may be added. The mixture is finely ground and burnt, driving off carbon dioxide and forming a clinker which is ground to make cement.
The aggregate is either crushed andesite from the Barton Rd quarry or greywacke from one of the quarries in the western part of the district.



Cross Arawa and continue along Broadway

Broadway-Tainui St corner.
Note the sculpture 'Family Group' (4) by local sculptor Saskia Riemersma, on the median plot. This is carved from a block of the lower pumice-poor Ongatiti Ignimbrite (Hinuera Stone), the rock used in the annual Matamata sculpture symposium.

Turn into Tainui St and walk south towards the Memorial Centre.

Farmers (5) [illegible]. The wall of the building is made of Huntly brick. The clays used in making these bricks come from the Huntly coal measures and were laid down in swampy conditions which resulted in most of the iron in the parent material being leached out. The absence of iron accounts for the light colour of the bricks. Further down the street you can see examples of red bricks made from ordinary yellow clay which turns red when fired because of its iron content,

Memorial Centre (6). The cenotaph is made of a stone usually called 'Coromandel Granite'. However, it is not a granite but Tonalite, an intrusive igneous rock from Paritu on the west coast of the Coromandel Peninsula, where it was quarried from about 1900 until the 1950s. It was widely used as an ornamental stone in buildings and as an a monumental stone. At Paritu it occurs as part of the Paritu pluton, a large body of igneous rock which has cooled slowly at depth beneath the surface of the earth. The slow cooling has resulted in the formation of large crystals of quartz and feldspar with some dark-coloured minerals, mainly hornblende and biotite. Most of the pluton consists of quartz diorite, a coarse-grained equivalent of andesite, of which tonalite is a variety. The tonalite contains inclusions (xenoliths) of greywacke plucked from the walls of the magma chamber and changed in both chemical composition and appearance because of the high temperature of the magma. Some of these inclusions can be seen in the cenotaph.

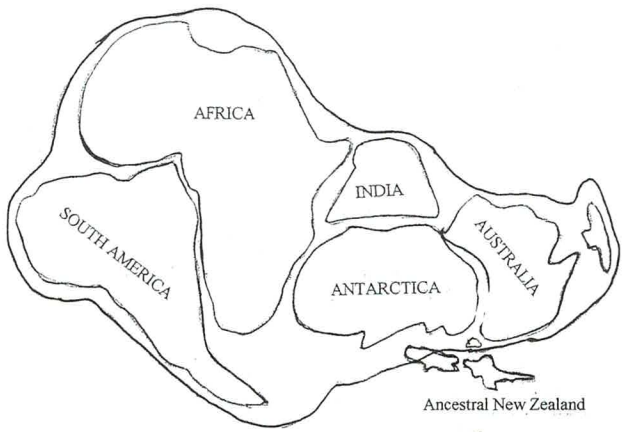
Continue along Tainui St to the entrance of the Centennial Drive (7). The large rock bearing the plaque is part of a column of Ontatiti Ignimbrite brought here from the Hinuera Valley.

Walk through the Centennial Drive, cross Rata St and reach the Viola Bell Magnolia Grove (8). Here the rock bearing the plaque is from the Waitearíki Ignimbrite. It was brought here from the top of the Kaimai Range.
The paving surrounding the seats is from one of the andesite outcrops east of Tauranga harbour. The rock is notable for the platy structure which makes it ideal for paving slabs and decorative work. The platy structure results from shear stresses which develop in the lava flow as it cools. Some of the slabs show on their surfaces moss-like structures (called dendrites) which resemble fossil plants but are really aggregates of manganese crystals.

Continue along the Drive to Tamihana St. On the left is a pool with a central rock (9). This and the other rocks round the pool are greywacke. They show veining with white minerals, quartz and zeolites, showing that the greywacke has been deeply buried before being uplifted.

Continue along the Drive. Walk through the McCaw native block. Near the Tawa St end is a cairn in memory of John McCaw. This is constructed of hard, dense, dark-coloured Kiwitahi basaltic andesite from Henry Watson Rd at the foot of the Te Tapui and Maungakawa volcanoes (see p. 19).

Cross Tawa St and enter the Broadway block. At the Broadway entrance to the Drive (10), is a group of large rocks brought here from the Hinuera Valley. These are part of the Ahuroa Ignimbrite, age about 1 million years. The Ahuroa Ignimbrite overlies the Ongatiti Ignimbrite and was erupted from the Mangakino Volcanic Centre.



GONDWANA

The super-continent of Gondwana began to break up about 70 million years ago through the processes of rifting and sea-floor spreading.

Continental Drift and the theory of Plate Tectonics

The idea that the continents could have moved relative to one another was developed by Alfred Wegener (1880-1930), who observed that there was a good match between the coastlines of Africa and South America and that rock strata and fossils on the two coasts were remarkably similar.

Wegener's theory gained little support because no-one could imagine a mechanism by which the continents could move.

After the second world war oceanographic research showed the presence of mid-ocean ridges along which volcanism was continuously producing new crust which spread out to either side, forcing the oceanic crust of the sea floor along until it was consumed in subduction zones along the continental margins.

By the 1970s it was realised that the whole of the earth's crust was divided into large pieces, called 'plates', which were in constant motion relative to one another. The idea of continental drift was refined into the theory of plate tectonics. Today plate tectonics is a cornerstone of geological science.

GLOSSARY

of terms used in the text

ALLUVIAL FAN: A fan-shaped deposit of alluvium formed where a stream passes from a narrow mountain valley on to a plain.

ALLUVIUM: A general term for deposits made by rivers. It consists of silt, sand and gravel.

ANDESITE: A volcanic rock intermediate in chemical composition between basalt and rhyolite. In appearance it is usually dark with a scattering of lighter-coloured mineral crystals. The typical andesite volcano is a composite cone, or 'strato-volcano', made up of alternating layers of lava and scoria, e.g. Mt Ngaruahoe, Mt Egmont/Taranaki.

BIOTITE: A form of mica, black in hand specimen.

BRECCIA: A body of broken, angular rock fragments. A volcanic breccia may consist mainly of scoria.

BULK DENSITY: The weight of a material divided by its volume, including the pore spaces.

CALDERA: A large, circular, crater-like feature formed by the collapse of the surface rocks after a very large rhyolite eruption such as those which produced voluminous ignimbrite flows. e.g. the basin of Lake Rotorua .

CARBON DATING: a dating method based on the decay of radio-active carbon 14 to carbon 12, a process which occurs at a known rate. It is suitable for use on materials less than 50,000 years old.

COROMANDEL GRANITE: See **TONALITE.**

COROMANDEL VOLCANIC ZONE: A volcanic region active between about 16 million and about 3 million years ago. It stretches from the Coromandel Peninsula through the Kaimai Range to merge with the Volcanic Plateau (TVZ). Large volumes of rhyolite, plus andesite and a little basalt were erupted. By 1.7 million years ago the active volcanic arc had shifted south-eastward to the Taupo Volcanic Zone.

CRUSH ZONE: A zone of broken rock along a fault surface or fault plane. Crush zones allow easy passage of fluids and so may be important aquifers of zones of mineral deposition.

DENDRITE: A branching pattern of deposited minerals on a rock surface, often mistaken for fossil plants such as mosses.

DIKE: A tabular body of igneous rock that intrudes more or less vertically through the pre-existing rocks. If the surrounding rock is eroded away the dike may be left as a steep-sided ridge.

DIORITE: See **QUARTZ DIORITE.**

EROSION: The transport of weathered rock materials by water, gravity or wind.

FAULT LINE: The intersection of a fault with the earth's surface.

FAULT SCARP: A cliff parallel to the fault line, produced by movement on the fault.

FELDSPAR: The most important group of rock-forming minerals. They make up about 60% of the earth's crust and are essential components of most igneous rocks. They are aluminium silicates of sodium, potassium and calcium.

FORMATION: A fundamental geological unit based on the physical characteristics of the rock, usually consisting of a single rock type or combination of related types, e.g. a series of tephras which are all eruptive material but may come from different sources and be of different ages. Usually named for the place where the formation was first described, often combined with the dominant rock type, e.g. Hamilton Ash Formation.

FOSSIL: the remains, trace or imprint of a living organism preserved in rock.

GONDWANA: The ancient super-continent which, during the Mesozoic era, split up to form the modern continents of India, Africa, Australia, South America, Antarctica and New Zealand.

GREYWACKE: a hard, grey sandstone which forms the undermass of much of New Zealand, including the Southern Alps, the main North Island axial ranges and hilly areas in other parts of the country.

HAMILTON ASH FORMATION: A set of volcanic ash beds, the oldest of which is the Rangitawa tephra, dated at about 350,000 years BP. Most of the beds have fossil soils, indicating a considerable time interval between the deposition of one bed and the next. Hamilton Ash is found at many localities throughout New Zealand.

HINUERA FORMATION: A set of alluvial sands, gravels and silts deposited in the Hamilton and Hauraki Basins during the Last Glaciation, the period between 50,000 and 15,000 years ago.

HOLOCENE: The most recent period of geological time, the upper division of the Quaternary. Also referred to as the Recent.

HORNBLENDE: A dark green or black silicate mineral found in volcanic rocks. It occurs in the Hinuera Formation as elongated, jet black crystals up to 2mm in length., an indication of the volcanic origin of the materials which make up this alluvial deposit.

HYDROTHERMAL ALTERATION: The chemical alteration of rocks due to the passage of hot, mineralised fluids.

HYPERSTHENE: An iron magnesium silicate mineral, an important constituent of many igneous rocks. It occurs in the Hinuera Formation as small yellow-green crystals.

IGNEOUS ROCK: A rock that has solidified from molten material (magma). Cooling may take place on the surface of the earth (volcanic rocks), at shallow depth (hypabyssal rocks) or at great depth (plutonic rocks).

IGNIMBRITE: A rhyolitic volcanic rock formed by the eruption of hot fragments of rock associated with voluminous gases in a pyroclastic flow (pyro = fire, clastic = made up of clasts or fragments of rock). The fragments may weld together to form a hard rock, or may take the form of a soft non-welded deposit.

INTRUSION: An igneous rock mass formed by the emplacement of magma in pre-existing rock.

KARAPIRO FORMATION: A set of alluvial gravels, sands and silts deposited in the Hamilton and Hauraki Basins between 350,000 and 1 million years ago.

KAUROA ASH FORMATION (K Beds): A set of volcanic ash beds dating from about 2 million years to about 1 million years ago. The oldest member is thought to be the airfall component of the Waiteariki Ignimbrite eruption.

LAHAR: a debris flow on the flanks of as volcano, especially an andesite strato-volcano. A lahar may be triggered by an eruption, by an escape of water from a crater lake (as in the Tangiwai disaster), or by heavy rainfall. Andesite mountains like Ruapehu and Egmont have a wide apron of lahar deposits round their lower flanks.

LITHICS: fragments of rock found within an ignimbrite flow.

MAGMA: Molten rock at depth in the earth's crust. Magma includes volatile substances which escape as gas during an eruption, so lava and other solid products of the eruption do not represent completely the composition of the original magma.

MAGMA CHAMBER: An underground reservoir of magma in the earth's crust. It holds magma derived from sources deep in the mantle.

MAGNETITE: An iron magnesium silicate mineral. It occurs in the Hinuera Formation as small black crystals.

MANTLE: The zone within the earth which extends from the base of the crust to the core.

OBSIDIAN: volcanic Glass, usually black but sometimes brown or red, usually rhyolitic in composition, formed as a result of very rapid cooling of the lava.

PALEOSOL: a 'fossil soil' - a soil which has been buried beneath other deposits, especially younger tephras or loess. The structures developed in a mature soil can still be recognised in a paleosol.

PLUTONIC ROCK: An igneous rock formed by cooling at great depth in the earth's crust. Slow cooling results in the formation of

large crystals. This gives the rock a coarse-grained appearance. Granite is a good example.

PLUTON: A massive body of plutonic rock.

PYROCLASTIC FLOW: A flow of hot fragments and associated gases produced in an eruption. An ignimbrite is a large-scale pyroclastic flow; a smaller scale one is sometimes referred to as a nuee ardente.

QUARTZ DIORITE: A coarse-grained plutonic rock, roughly the plutonic equivalent of andesite.

QUATERNARY: The most recent division of the Cenozoic era. It comprises the Pleistocene and Holocene periods.

RADIOMETRIC DATING: a dating technique based on the decay of radioactive isotopes at known rates to form new substances,e.g. uranium-lead, potassium-argon, rubidium-strontium.

RECENT: See Holocene.

RHYOLITE: A volcanic rock high in silica and light in colour. Rhyolites are very viscous and if the magma is rich in gases highly explosive eruptions may result. If the magma is gas-poor, rhyolite domes such as Te Weraiti or Mt Ngongotaha are formed.

RIFT: (or "rift valley") An elongated topographical depression resulting from movement on faults. Where a block has sunk because of movement on parallel bordering faults the feature is called a graben; where movement is confined mainly to one bordering fault the result is a fault-angle depression.

SEDIMENTS: Silts, sands and gravels transported by and deposited under water.

SHARD: A small (<2mm) angular fragment of volcanic glass. In the Hinuera Formation most of the glass shards are derived from fragmented pumice.

SOIL: A soil is the product of weathering of a parent material. A mature soil takes a long time to develop, perhaps a thousand years or more. A mature soil has an upper or 'A' horizon, or topsoil, which contains organic matter (humus) and is usually dark in

colour, from which minerals have been washed down into the 'B' horizon, or subsoil. The 'B' horizon often shows a characteristic blocky structure. The 'C' horizon consists of weathered parent material.

SLUMP: The downward movement of a mass of rock or debris moving as a unit over a slide plane.

SWALE: A long, narrow depression between braid bars in a braided river system.

TAUPO VOLCANIC ZONE (TVZ): A zone of active volcanism stretching 200 km from Ohakune to the Bay of Plenty, related to subduction along the plate boundary between the Australian and Pacific crustal plates. It is the southern extension of the Tonga-Kermadec oceanic island arc into the continental crust of the North Island. Large volumes of rhyolite, some andesites and occasional basalts have been erupted over the last 1.7 million years. It is a region of crustal extension and is widening at up to 11mm a year.

TECTONIC: Related to large-scale movements in the earth's crust, e.g. along fault lines or plate boundaries.

TEPHRA: A general term for fragmental material ejected from a volcano during an eruption and transported through the air. May include ash, lapilli (little stones), volcanic bombs and boulders.

THERMAL GRADIENT: The increase in temperature which occurs with increasing depth in the earth, usually 25-30^{0}C per km in non-volcanic areas.

TONALITE: A variety of quartz diorite, a plutonic igneous rock consisting mainly of quartz and feldspar with some dark-coloured minerals such as hornblende and biotite.

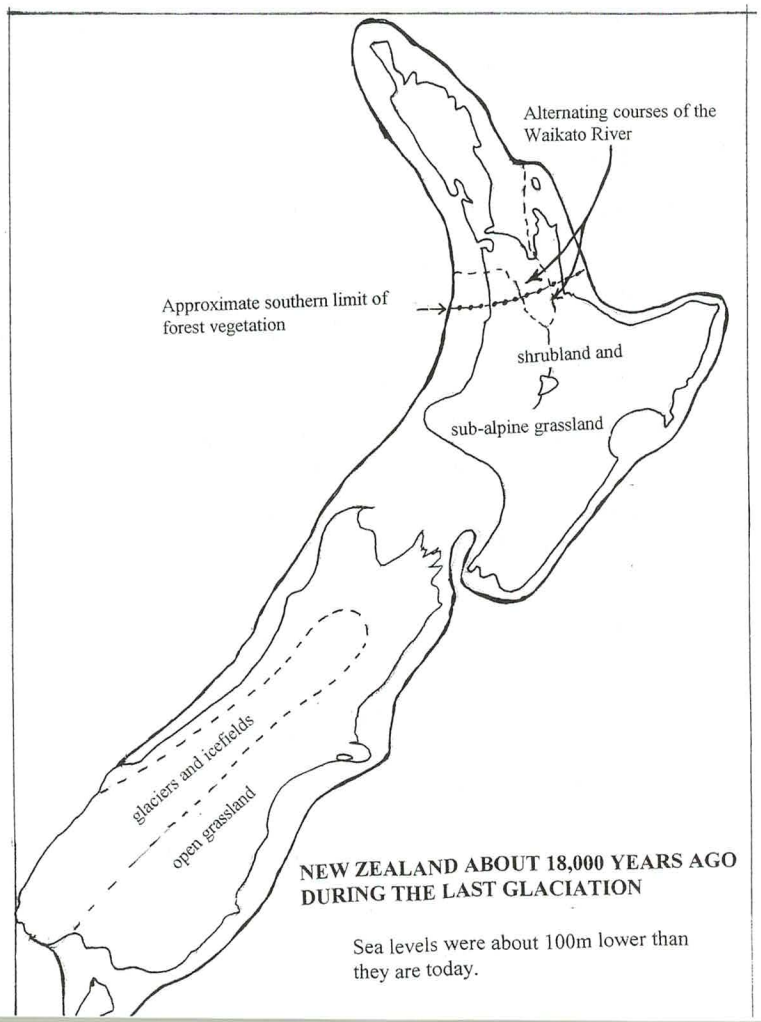
TURBIDITY CURRENT: a bottom-flowing current laden with suspended sediment, which moves swiftly down a submarine slope and spreads horizontally. The sedimentary load is dropped dropped as the current slackens, giving rise to characteristic sediments called turbidites.

VOLCANIC ASH: Fine material ejected from a volcano during an eruption. Ash may be carried for long distances by the wind. See TEPHRA.

WEATHERING: Rock breakdown by chemical changes, e.g. oxidation, which produce new minerals, or by mechanical processes, e.g. freeze-thaw.

XENOLITH: (Greek = foreign rock) A rock fragment included in an igneous rock, that is different from the rock in which it is found. Often xenoliths are pieces of 'country rock' torn from the sides of the magma chamber or the volcanic vent.

ZEOLITES: A group of minerals, mainly aluminium silicates of sodium, potassium or calcium.



NEW ZEALAND ABOUT 18,000 YEARS AGO DURING THE LAST GLACIATION

Sea levels were about 100m lower than they are today.

REFERENCES

Beanland, S; Berryman, K: 1986. 'The Kerepehi Fault, Hauraki Depression'. *N Z Geol. Surv. E .D.S. Immediate Report 86/27.* DSIR Wellington.

Bowling, F M 1989 'Volcanic Geology of Ignimbrites on the Western Margin of the Hauraki Depression and in the Maungatautari Area'. *Unpublished M Sc thesis, University of Waikato*

Briggs, R M 1986: Volcanic Rocks of Waikato Region, in *Late Cenozoic Volcanism in New Zealand.* Roy.. Soc. N Z Bulletin 23 p 76-91.

Briggs R M; Gifford, M G et al 1993*:* Geochemical zoning and eruptive mixing in ignimbrites from the Mangakino Volcano, Taupo Volcanic Zone, New Zealand. *Journ. Volc. and Geothermal Research 56*, 175-203.

Briggs, R M; Hall, G J; Harmsworth, G R et al 1996: Geology of the Tauranga Area, sheet U14 1:50000. Dept of Earth Sciences, University of Waikato, occasional report No 22.

Carter, L; Carter, B et al 1999: You don't know what's there till you drill: initial results from Leg 181 - S W Pacific Gateway. *Water and Atmosphere v7 no 1.* NIWA.

:

Cuthbertson A S 1981: The Hinuera Formation in the southern Hauraki lowland, central North Island. *Unpublished thesis, University of Waikato.*

Edwards, B 1954*:* Mr John Dalton, Sandman. *Commercial Horticulture (July) p 16-19*

Healy, J: Schofield, J C; Thompson, B N 1964*:* Geological Map of New Zealand, Sheet 5, Rotorua. DSIR Wellington

Henrys, A S, Hochstein M P 1985: A Geophysical Reconnaissance Survey of Great Barrier Island, North Island, NZ. *Journ. Geol. and Geophys. 28: 383-395.*

Hochstein, M P et al 1984*:* Hauraki Rift. *Proc. 1984 Symposium on Recent Crustal Movements of the Pacific Region. Bulletin Roy. Soc. NZ*

Hochstein, M P; Tierney, K; Rawson, S et al 1986: Structure of the Hauraki Rift, in Reilly, W I; Harford B E (Eds): *Recent crustral movements of the Pacific Region.* Roy Soc NZ Bulletin 24, 333-348.

Houghton B F and Cuthbertson, A S 1989*:* Sheet 14 BD - Kaimai. Geological Map of NZ 1:50,000. DSIR Wgtn.

Houghton, B F; Wilson C J N, McWilliams, M O et al 1995: Chronology and dynamics of a large silicic magmatic system, Central Volcanic Zone, New Zealand. *Geology 23:1* p 13-16.

Hume T M ; Sherwood A M; Nelson C S 1975*:* Alluvial sedimentation of the Upper Pleistocene Hinuera Formation, Hamilton Basin, N Z. *Jour. Roy. Soc. NZ v5 no 4* 421-462.

Kear,D; Schofield, J C 1978: Geology of the Ngaruawahia Subdivision. NZ Geological Survey Bulletin 88, DSIR Wgtn.

Kear, D 1993: Reflections on major North Island basement rock assemblages and on megafaults. *Journ Roy Soc NZ 23:1* p 29-41.

Kear, D 1999: New Zealand's Volcanoes - their story. David Kear, Whakatane.

Lowe, D J et al 1999: Zircon fission track ages on weathered Plio-Pleistocene tephra sequences, western North Island, New Zealand. *Quaternaire* (in Press)

Manville, V 2001: Environmental impacts of large-scale explosive rhyolite eruptions in the central North Island. Geol. Soc. N.Z. Conference Field Trip Guide, 2001.

Milner, D M; Cole J W, Wood, C P 2000: Geochemistry and emplacement of the c. 225ka Mamaku Ignimbrite. *Abstracts, Geol Soc NZ conference.* Geol Soc NZ Miscellaneous publication 108A, p 102.

Nairn, I A 1980: Source, age and eruptive mechanisms of Rotorua Ash. *NZ Journ. Geol and Geophysics,23:2* , 193-207.

Newnham, R M; Lowe, D J; Willaims, P W 1999: Quaternary environmental change in New Zealand : a review. *Progress in Physical Geography v 23 no 4*, 567-610.

Newnham, R M; Lowe, D J: Alloway, B V 1999: Volcanic hazards in Auckland, New Zealand, in Firth, C R: McGuire, W J (eds): *Volcanoes in the Quaternary.*

Olissof, E S 1981" Quaternary stratigraphy and ignimbrites of the Karapiro-Arapuni region. *Unpublished MSc thesis, University of Waikato.*

Pillans, B; Kohn, B; McGlone, M 1992: Rangitawa tephra. *Geol. Soc. NZ Newsletter No 95*, 42-46

Pullar, W A; Birrell, K S 1973: Age distribution of Late Quaternary pyroclastic and associated cover deposits of the Rotorua and Taupo area, North Island, New Zealand. NZ Soil Survey Report.

Selby, M J 1967: Aspects of the geomorphology of the greywacke ranges bordering the lower and middle Waikato Basins. *Earth Sc Journ vol 1 no1*, Waikato Geological Society.

Selby, M J; Lowe, D J 1992: The middle Waikato basin and hills, in *Landforms of New Zealand*, ed. Soons J M et al, 2nd ed. Longman Paul. p 233-255.

Skinner, D N B 1986: Neogene volcanism of the Hauraki Volcanic Region, in *Late Cenozoic Volcanism in New Zealand*, ed. Smith, I E M. Roy Soc NZ Bulletin 23, p 21-47.

Stanley, R D 1989: Watkins' Stone Kitchen - an unusual stone building near Matamata. *Geol Soc NZ Newsletter no 86*, 28-29.

Stanley, R D 1991: A fossil of Monotis richmondiana from Hyndeman's Quarry at Kiwitahi. *Geol Soc NZ Newsletter no 94*, 54-55.

Stanley, R D 1994: Pre-Hinuera fluvial deposits of the Karapiro Formation at Kirk Rd and Scherer's Rd near Matamata. *Geol Soc NZ Newsletter no 104*, 43-51.

Ward, W T 1967: Volcanic ash beds of the lower Waikato Basin, North Island, New Zealand. *NZ Journ Geol and Geophysics v.10 no 4*, 1109-1135.

Wilson, C J N: Houghton, B F 1995: An exceptionally widespread ignimbrite. *Nature v 378* Dec. p605-607

FURTHER READING

Aitken, J J 1996: Plate Tectonics for Curious Kiwis. IGNS Lower Hutt.

Cox, G J; Hayward, B W 1999: The Restless Country. Harper-Collins, NZ.

Hayward B W 1990: Trilobite, Dinosaurs and Moas Bones. The Bush Press, Auckland.

Hayward, B W; Gill, B J 1994: Volcanoes and Giants. Auckland Instutute and Museum, Auckland.

Stephens, Graeme 1985: Lands in Collision. NZ Geol.Survey, Wgtn.

Stephens, G; McGlone, M; McCulloch, B 1988: Prehistoric New Zealand. Heinemann Reed, Auckland.

Thornton, J. 1985: Field Guide to New Zealand Geology. Reed Methuen, Auckland

Supplementary notes

THE ORUANUI AND TAUPO ERUPTIONS OF THE TAUPO VOLCANO, TAUPO VOLCANIC ZONE, NORTH ISLAND, NEW ZEALAND

The Oruanui eruption, 26,500 years ago.

The Oruanui eruption was centred in the northern part of what is now Lake Taupo.

Prior to the Oruanui eruption the Taupo-Reporoa structural graben (or rift) had been occupied by a lake for > 100,000 years of relative quiet after the very large eruptions of the Mangakino and Whakamaru Volcanic Centres.

The Oruanui eruption is the latest of the large (>100 km^3 of magma) caldera-forming events of the TVZ. It was a landscape forming event, whereas the smaller 1.8 ka Taupo eruption was a landscape modifying event. It created the Taupo area as we see it today, but the products of the eruption and the nature of the caldera are well disguised because the vent lies under Lake Taupo and the eruption products have been distributed over a wide area.

The Oruanui eruption produced 430 km^3 of fall deposits, mainly volcanic ash, 330 km^3 of ignimbrite 420 km^3 of other volcanic material, equivalent to about 530 km^3 of magma. There were ten phases to the eruption giving rise to mappable ash fall units (or ash beds). The eruption was episodic, with months between phases. The entire countryside within 80 km of the vent was buried in up to 200 metres of pyroclastic material, while ash covered the southern half of the North Island and the N.E. South Island. At the Chathams there was an ash fall 100 mm (4") thick. Ignimbrite deposits range from over 200m thick near the vent to a few centimetres at 90 km away in a flow which travelled at 100m per second (360 km/hr). The ignimbrite is unwelded because it was erupted through the lake, resulting in emplacement temperatures of 150 to 270 degrees C . The pre-existing lake was destroyed in the eruption and eventually replaced by the present lake.

Deposition of ignimbrite had the greatest impact on the landscape, destroying the lake that had occupied the Taupo-Reporoa for over 100,000 years and burying the whole land surface.

Modern Lake Taupo partly fills the Oruanui crater; a 140 km^2 structural collapse area is concealed beneath the lake. The southern part of the lake was formed by accompanying tectonic collapse. When the lake re-filled, its surface was 140m above the present lake level since all the old drainage outlets had been buried by the ignimbrite.. This old high-stand shoreline remains a present day landscape feature.

Eventually a catastrophic break-out flood down the Waikato gave rise to a major sedimentation event resulting in the deposition of coarse fluvial beds (including boulder beds) up to 100 km downstream and the formation of a major fan surface along its pre-eruption course through the Hauraki depression. The Hauraki plain is big braid plain formed of 120 km^3 of Oruanui eruption products making up the Hinuera Formation and the Hinuera Surface. Continued aggradation led to the river breaking through its banks at Piarere and changing course into the Hamilton Basin, where fan building continued, forming the present-day Waikato lowland plain.

The eruption occurred two or three thousand years before the peak of the Last Glacial Maximum, in dry, cool, periglacial conditions. As a result vegetation was slow to become established, leaving bare surfaces of soft unwelded ignimbrite and ash easily eroded and available for transport by rivers. until about 17,000 years ago when climatic warming led to re-afforestation, a decline in sediment yields, and entrenchment of rivers. Landscapes became stabilised about 12,000 years ago, 14,000 years after the eruption.

This sequence of events is an analogue of what happened following the huge eruptions of the Mangakino Volcanic Centre a million years ago, leading to the emplacement of the Karapiro Formation in the Hauraki and Waikato Basins.

The Taupo Eruption, AD 181 (1,800 years ago)

This was the next major eruption of the TVZ. Although is the largest eruption anywhere on earth in the last 5000 years it was much smaller than the Oruanui, about 35km^3 of magma.

The eruption took place in six stages over days or weeks and culminating in the eruption of the 30km^3 unwelded Taupo Ignimbrite. Each stage produced a distinctive tephra layer according to magma-water interactions, ranging from fine ash (wet) to fragmented pumice lapilli (dry). The eruption column reached high into the stratosphere (50 km) allowing fine ash and aerosols to spread round the globe, giving spectacular sunsets in Europe. Traces of Taupo ash have been found in Iceland peat bogs.

By the end of stage 5 so much magma had been erupted that the roof of the magma reservoir was unsupported and collapsed, leading to the ignimbrite eruption which flowed outwards at up to 900 km/hr and reached some 90 km from the vent, destroying 20,000 km^2 of forest and other vegetation which had developed undisturbed since Oruanui times. The charred trunks of these forest trees can be seen in the ignimbrite deposits, unlike the Oruanui ignimbrite which was erupted over a landscape of sub-alpine shrubs and grasses which left no trace. The flow topped Mt Tongariro and the Kaimanawas, filled river valleys and ponded in low-lying areas.

The Taupo eruption was a landscape modifying event rather than a landscape forming event like the Oruanui.. It destroyed drainage over an area of 20,000 km^2 when the emplacement of ignimbrite filled valleys and depressions and blocked the outlet of Lake Taupo.

A temporary lake formed in the Reporoa Basin behind an ignimbrite dam across the Waikato River at Orakeikorako. At its maximum it occupied an area of 190 km^2, impounding approximately 2.5km^3 of water. It filled to its maximum height within three years of the eruption, and when the water level overtopped the ignimbrite dam failure is inferred to have been rapid, triggering a large flood which emptied the lake.

After the eruption the eruption products were available for re-distribution by rivers. Huge mud flows (lahars) followed the courses of the major rivers such as the Whanganui.. The Waikato River outlet from Lake Taupo was blocked by an ignimbrite dam. After about 20 years the lake had refilled to a level 33m above its present level.. The rising waters overtopped the ignimbrite barrier starting a breach which released 20 km^3 of floodwater down the Waikato Valley. Downstream aggradation from the mass of eruptive material carried down by the break-out flood partially infilled the trench cut by the Waikato through the Hinuera fan surface after the end of the Last Glaciation, forming a terrace on which the Cambridge golf course and the Hamilton Gardens are located.

The final stage of the Taupo eruption occurred about 30 years after the main event when lava domes were erupted under the lake to form the Horomatangi Reef and the Waitahunui Bank. Big blocks of pumice (up to17m long) broke off the growing domes, floated, and were driven by the wind on to the eastern shore where they can be seen on the eastern side of SH1 just past the airport

Because the eruption occurred under climatic conditions similar to our own and favourable to plant regeneration, recovery was rapid. New forests had become established and the landscape stabilised within two hundred years of the eruption, much more quickly than after the Oruanui eruption.